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Applications of Artificial Intelligence (AI) in Business Entrepreneurship and Start-Ups: A Systematic Literature Review and Bibliometric Analysis

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ABSTRACT

Artificial Intelligence (AI) is transforming entrepreneurship by enabling data-driven innovation, strategic decision-making, and operational agility; however, its adoption remains uneven and fragmented due to technological, organizational, and contextual barriers. This study examines the applications, trends, and intellectual structure of AI-driven entrepreneurship through a systematic literature review and bibliometric analysis, employing the SPAR-4-SLR protocol to analyze peer-reviewed English-language articles retrieved from the Scopus database published between 2004 and 2025. The performance analysis and science mapping of 245 relevant publications was done using Biblioshiny and VOSviewer. The results demonstrate that the research output has increased exponentially since 2018 as a result of the merging of AI technologies and entrepreneurial innovation. Major AI applications have been found in marketing and customer interaction, product development and innovation, decision-making and strategy, financing, entrepreneurship education, and operational performance. The factors that support adoption include technological readiness, data-driven culture, and capability development, whereas the hindering ones are the lack of resources, the problem with data quality, and ethical and governance concerns. Thematic and key-word co-occurrence analyses demonstrate the emergent research areas of AI-enabled entrepreneurship, digital transformation, innovation, and generative AI, which highlights the increased interdisciplinarity of the domain. This study presents organized thematic taxonomy and suggests a future research paradigm, which can be of great use to researchers, entrepreneurs and policymakers who would be running AI-based entrepreneurial ecosystems.

1 | Introduction

The fact that the convergence between Artificial Intelligence (AI) and entrepreneurial practice is accelerating is altering how business ventures are initiated, operated, and grown in the modern dynamic business environment. Similar to the disruptive impact that internet growth had on the banking industry [1], AI offers new ways of businesses to be innovative, communicate, and adapt to market dynamics. The recent developments in machine learning, natural language processing, and generative AI allow companies, both large and small, to automatize complex operations, extract hidden information

in large amounts of data, and make strategic decisions unlike any before [2, 3]. These advances go beyond operational back-end advances to include fundamental business-model change and entrepreneurship.

Historically, the use of technology in business was linked to large resource endowed companies. Small firms and start-ups have reduced barriers to entry due to the democratization of AI tools via cloud computing, open-source systems and plug-and-play AI platforms [4]. This change is making entrepreneurs rethink the way they create competitive advantage at the very beginning. The use of AI to scan the market in real-time, segment the customers, and cycle product development now enables quicker pivoting and enhanced product-market fit. As with the digital banking, which forced institutions to reevaluate their relationship with customers [5], AI is calling on businesses to restructure their internal and external value propositions around smart systems. However, the entrepreneurial and start-up context is a highly underexplored area, despite an increasing number of studies investigating the implementation of AI in the traditional business processes, including supply chains, finance, and customer service [6]. Entrepreneurial companies have special limitations, including insufficient capital, limited time, and excessive uncertainty in the market, which make their AI implementation process fundamentally different compared to major companies [7]. Further, the reasons supporting implementation of AI in start-up enterprises are often not limited to efficiencies, but encompass opportunity identification, fast experimentation, and signaling investor value [8]. These subtle trends have not been adequately theorized in the existing business and management literature.

In this paper, the author aims to synthesize the existing research on the subject of AI in entrepreneurship and business comprehensively, systematically, and based on the bibliometrics. Although a number of narrative reviews and technology-oriented articles have been published in the recent past, none of them has been sufficiently able to map the evolution of the field, the intellectual organization, and the patterns of application of the field in an integrated scholarly approach. Similar to the recent research that has utilized bibliometric techniques to the more general area of digital banking and payments [9–11], the present study uses bibliometric methods in addition to the SPAR-4-SLR review protocol with PRISMA model [12] to identify trends, gaps, and future directions in AI-entrepreneurship research.

1.1 | Background and Context

Artificial Intelligence (AI) technologies are becoming increasingly influential in entrepreneurial ecosystems, providing start-ups and new ventures with the ability to test, learn and scale in a more intelligent way than ever before. For the purpose of this study, a "start-up" refers to an early-stage, innovation-driven venture operating under conditions of high uncertainty and resource constraints, with strong scalability ambitions and technology-enabled business models [13]. Unlike traditional small and medium-sized enterprises (SMEs), start-ups are typically experimentation-oriented, growth-focused, and embedded within dynamic digital ecosystems. This distinction is important because AI adoption patterns in start-ups differ significantly from those in established firms [14, 15]. Startups are also more likely to utilize AI in a disruptive way unlike traditional companies, which often introduce AI gradually and within the framework of the existing organizational structures [15, 16]. Similarly, AI start-ups are also currently creating so-called AI-native strategies where automation, data analytics, and algorithmic decision-making are integrated into the core operations at their inception [17].

Start-ups are also progressively using AI in a variety of applications, including automating customer experience using intelligent chatbots and using predictive algorithms to match investors, credit scores, and coordinate the supply chain [18]. These applications explain the way AI can enable early-stage companies to act more effectively and strategically, despite resource limitations. In this respect, AI acts as a cognitive enhancement, allowing founders to authenticate the newly emerging market opportunities, gauge competitor action, rank product attributes, and test business hypotheses [19]. As an illustration, AI-based tools will be able to monitor the mood of social media, examine customer reviews on the fly, or propose changes in digital marketing tooling or pricing algorithms.

Moreover, a significant number of the studies are dedicated to particular technology (e.g., machine learning in marketing) or the digital transformation, in general, without narrowing down to the cases of entrepreneurial application of AI. The areas of dominance of application (e.g., customer analytics versus operations versus funding), geographical areas of application (developed versus emerging markets), and methodologies (qualitative versus bibliometric versus conceptual models) are also not clear [20]. This fragmented land prevents the researchers to draw generalisable conclusions or build grounded theories.

Inspired by bibliometric analyses conducted in the digital banking domain, which identified research trends across more than 1900 articles [9], this study extends that approach to investigate developments in AI and entrepreneurship. The thematic patterns, co-authorship networks, and the citation impacts are clustered and visualized with the help of unsupervised machine learning, which is a method of bibliometric analysis, and is also powered by AI [11]. Bibliometrics, together with the transparent review process of the SPAR-4-SLR enables researchers to go beyond what is described on a surface level and generate actionable and future-oriented insights.

In this study, there is a two-pronged methodology to investigate the AI landscape in the field of entrepreneurship research in a systematic way. First, performance analysis is used to assess the most important metrics of publications, such as trends over time, the most active articles and journals, the most productive authors, institutions, and countries. In this analysis, the scholarly impact points are determined where the impact is centred and the field of output and collaboration is determined.

Second, science mapping reveals intellectual and conceptual framework of the discipline. Through co-citation patterns,

co-occurrences of keywords and thematic clusters, the approach produces the prevailing themes of research, subtopics that interrelate and areas of investigation that emerge. Collectively, these methods offer a holistic perspective on productivity, as well as knowledge organization, of AI-based entrepreneurship studies.

This study is guided by the overarching question: How has research at the intersection of artificial intelligence and entrepreneurship evolved in terms of publication trends, intellectual structure, thematic domains, and future directions?

This broad inquiry is operationalized through the following specific research questions:

RQ_1: What are the publication trends in AI and entrepreneurship research?

RQ_2: Which are the most influential articles and journals in this incorporated domain?

RQ_3: Who are the top contributing authors and countries in the field of application of AI in Entrepreneurship?

RQ_4: What are the major themes, clusters, and applications of AI in entrepreneurship research?

RQ_5: What are the promising directions for future direction of studies in AI-driven business and venture creation?

2 | Theoretical Framework

2.1 | Digital Entrepreneurship Theory: AI as an External Facilitator of Venture Creation

Digital entrepreneurship theory conceptualizes digital technologies as hypothesized exogenous facilitators that reduce barriers to entry, redefine opportunity recognition, and alter value-creation mechanisms in the new venture creation [14, 21]. In comparison to traditional technological resources, digital technologies are characterized by programmability, scalability, homogenization of data and generativity, thus providing entrepreneurs with the ability to configure and recombine resources at a rapid rate [22]. Artificial Intelligence (AI) builds upon this reasoning by not only acting as infrastructure but a smart exogenous enabler with the ability to find opportunities, experiment as well as autonomously learn [23]. AI platforms can improve the ability of both entrepreneurs to perform analysis of large volumes of unstructured data, identify the new tendencies of the market, as well as model alternative business scenarios [7]. In this respect, AI can change the entrepreneurial thinking by enriching the scope of search and reducing information asymmetry.

The use of AI and generative components will enable quick prototyping and lean experimentation, which speeds up the iterative validation process that is at the heart of digital entrepreneurship [13]. Integration of AI in digital ecosystems therefore re-characterizes the process of identifying, evaluating, and exploiting entrepreneurial opportunities, and AI is offered as an enabling factor of modern venture creation.

2.2 | Dynamic Capabilities and Resource-Orchestration: AI as a Strategic Capability-Building Tool

The dynamic capabilities model assumes that companies achieve a long-term competitive advantage by being adaptable in their abilities to sense opportunities, capture them and reorganize resources when the environment is changing very fast [24]. These adaptive capabilities are essential in start-ups that are operating on uncertainty. The AI also helps to develop dynamic capabilities by enhancing sensing systems in the form of predictive analytics, pattern recognition, and processing, in real-time [25]. AI reinforced the detection of opportunities and responsiveness to the strategic environment because it enables continuous scanning of the environment and the automated feedback process.

According to the resource- orchestration perspective, entrepreneurs have to organize, package, and capitalize on resources in order to create value [26]. AI systems allow start-ups to optimize the process of resource allocation, automate operational processes, and combine knowledge resources [27]. It is especially common in resource-intensive businesses, where AI replaces limited human experience in integrating algorithmic intelligence into the core operations [28]. Therefore, AI is not to be seen only as a technological artefact but as a strategic competency that increases flexibility, scalability, and competitive positioning in the world of entrepreneurial systems.

2.3 | AI-Augmented Decision-Making Theory: The Anthrop-Artificial Intelligence Cooperation in Entrepreneurial Judgment

Within entrepreneurial decision-making, cognitive biases, uncertainty, and incomplete information are not structurally distinct elements [29]. Conventional studies on entrepreneurship focus on intuition, heuristics and effectuation logic in the initial phases of a venture [30]. However, AI creates a new paradigm of hybrid intelligence in which algorithmic analytics is used to supplement human judgment [31]. According to the AI-enhanced decision-making theory, the best results can be achieved through the symbiotic interaction of machine intelligence and human thinking [32]. AI can improve the quality of analysis by making predictions using modeling and simulating scenarios, whereas human-based entrepreneurs can give context and interpretations of the analysis, create ethical arguments, and strategic thinking. The augmentation would be relevant especially in venture strategy, investment decision-making, pricing optimization, and customer targeting [19]. Instead of replacing the judgment of an entrepreneur, AI reconfigures the processes of cognition by increasing the capacity of information-processing and shortening the time to make decisions [33]. In line with this, AI-based entrepreneurship is collaborative in its decisions, where the human-AI interaction is one of the key factors in venture performance and growth.

2.4 | Novelty and Business Model Transformation: AI-Scalability and Experimentation

Innovation processes and the design of business models are also fundamentally redesigned by AI. The theory of digital innovation focuses on the role of modular digital architectures that can facilitate recombination and scale quickly [34, 35]. This is enhanced by AI which helps in the automation of experimentation and allows data-driven iteration. Ideation, prototyping, and design optimization are speeded up using the generative AI tools, which decreases the time-to-market in new start-ups [36]. In addition, AI-informed analytics guide the pricing, personalization, and value proposition development, which leads the business model innovation to be scalable [37]. Scalable experimentation AI supports continuous A/B testing and real-time performance monitoring and algorithmic learning loops [38]. This falls in line with lean start up and integrates smart automation in the process of validation cycles. Also, AI-enabled systems help to create value built on ecosystems, where a venture can utilize network effects and growth through platforms [39]. This means that AI triggers the business model change process by allowing agility, scalability, and sustainable competitive advantage.

The above-discussed theoretical lenses put artificial intelligence into its place as more than a technological tool; it appears as a strategic enabler that is present throughout the principles of digital entrepreneurship, dynamic capabilities, and the theory of innovation. AI increases the ability to recognize opportunities, strengthens resource coordination, and improves the decision-making process by entrepreneurs using human-machine interaction. With the combination of sensing, experimentation, and scalable business model transformation, AI reorganizes the process of value creation and value capture in digitally mediated ecosystems among start-ups. These two theoretical approaches combined give a sound conceptual framework to understand AI-enabled entrepreneurship. This framework does not just corroborate the bibliometric results of the research, but also creates a systematized ground regarding the analysis of the developing intellectual infrastructure of AI applications in start-ups and new enterprises.

3 | Research Methodology

3.1 | Review Design and Methodological Rationale

The present study uses a systematic literature review (SLR) along with the bibliometric analysis to query an increasingly growing body of academic literature on the subject of artificial intelligence (AI) in the context of business entrepreneurship and start-ups. Due to the interdisciplinary nature of the field and its fast growth, a systematic and transparent review design is essential to ensure the methodological rigor, reproducibility, and overall analysis profundity. In this regard, the research will use the SPAR-4-SLR protocol outlined by [12], which provides a comprehensive outline of how academic literature can be collected, collated, evaluated, and disseminated as clearly visible in Table 1. The SPAR-4-SLR paradigm especially aligns well with applied AI studies, as it combines both the quantitative bibliometric processes and qualitative synthesis, thus allowing to both develop a robust cartography of intellectual structures and at the same time supporting theory-based interpretation.

TABLE 1 | Systematic review procedure using the SPAR-4-SLR protocol.

Assembling	Search keywords: ((((“AI” OR “Artificial Intelligence”) AND (“Business*”) AND (“Entrepreneur*” OR “startup*” OR “Start-Up*”))))
	Search database: Scopus.
	Search result: 1668 papers
Arranging	Organizing filters: Year, subject area, document type, publication stage, and language.
	Filtered year for inclusion: Up to “2004–2025”.
	Filtered subject area for inclusion: “Business, management, and accounting”.
	Filtered document type for inclusion: “Article”.
	Filtered publication stage for inclusion: “Final”.
	Filtered source type for inclusion: “Journal”.
	Filtered language for inclusion: “English”
	Filtered search result: 245 articles.
Assessing	Analysis method: Bibliometric analysis techniques, namely:
	“Performance analysis” (i.e., publication trend, most influential article and top contributing journal, author, institution, country). “Science mapping” via “temporary analysis using word clouds” (i.e., major topics) and “network analysis using keyword cooccurrence” (i.e., major themes)
	Agenda proposal method: Reading of articles and reflection of extant gaps for each major theme
	Reporting convention: Figures, tables, and words
	Limitation: Accuracy and completeness of bibliometric data from Scopus

Source: Authors' development.

3.2 | Assembling Stage: Data Source and Search Strategy

The assembling phase focuses on the systematizing of appropriate literature. The study relies exclusively on the Scopus database due to its extensive coverage of peer-reviewed journals in business, management, and technology domains, as well as its standardized and structured citation metadata. In

bibliometric research, the use of a single comprehensive database enhances consistency and avoids duplication or metadata incompatibility that may arise when combining multiple sources [9, 40]. However, future research may expand the scope by incorporating additional databases such as Web of Science to further triangulate findings. The use of the following search string was set to the titles, abstracts, and author keywords: TITLE-ABS-KEY—(("AI" OR "Artificial Intelligence") AND ("Business") AND ("Entrepreneur" OR "Startup" OR "Start-Up")) to find research in the intersection of artificial intelligence, business, and entrepreneurship. This search was a carefully developed search string that balances inclusiveness and relevance. The usage of various AI-related words made sure that the wide range of terminologies was covered, and wildcards such as start-ups, enabled capturing of all variations including entrepreneurial, entrepreneurship, and business models. The review period (2004–2025) was selected to capture the complete evolution of AI-related entrepreneurship research. Although the rapid expansion of AI applications in start-ups occurred after 2018, earlier studies from the mid-2000s laid the conceptual foundations by exploring intelligent systems, algorithmic decision-making, and digital opportunity recognition within entrepreneurship. Including the pre-2018 literature enables identification of the emergence stage and growth inflection point, ensuring accurate life-cycle and bibliometric analysis. Limiting the study to post-2018 publications would risk overlooking these foundational contributions. The information search limited the articles to papers in English so that the interpretation and synthesis would be consistent. The types of documents included journal articles, review papers, and conference proceedings because these types of documents reflect both conceptual and emerging applied research (see Figure 1).

3.3 | Arranging Stage: Screening and Selection Requirement

The arranging step entailed orderly optimization of the original data to guarantee conceptual relevance and quality. To eliminate duplicate records, reference-management software and spreadsheet checks were used first. Afterwards, title and abstract screening were performed to eliminate the publications that were purely concerned with the technical AI development and lacked a clear business, entrepreneurial, or start-up background.

After screening of abstracts, full-text eligibility screening was conducted to ensure that the abstracts were in line with the objectives of the study. This methodical procedure was used to end up with a final list of 245 documents upon which both bibliometric and qualitative analyses were carried out. The screening logic was based on the SPAR-4-SLR guidelines, which implies transparency and reproducibility.

3.4 | Assessing Stage: Bibliometric and Qualitative Analysis

The evaluation step had two complementary sub-elements: Qualitative thematic synthesis and bibliometric analysis. Bibliometric analysis was done to identify the intellectual, social, and conceptual framework of the surviving literature. There were descriptive indicators such as annual publication patterns, most popular journals, prolific authors, power institutions and contributions by country that were examined to explain how research activity was growing and diffusing. Citation analysis was used to find the documents of significant impact and knowledge underpinnings. Co-authorship analysis investigated patterns of collaboration between authors, between institutions, and between countries, and the keyword co-occurrence analysis shed some light on the dominant and developing research themes. The VOSviewer and Biblioshiny (the Bibliometrix package in R) were used to conduct such analyses because they are highly used tools in bibliometric studies due to their high level of robustness and visualization features [9, 41]. Thematic maps and network visualizations were then created to make them easier to interpret and synthesize. Simultaneously, a qualitative synthesis was carried out to question thematic clusters and conceptual patterns obtained with the help of bibliometric mapping. Instead of combining single studies, this synthesis focused on more abstract and integrative levels, which is in line with the best practices of systematic reviews. In addition to the SPAR-4-SLR protocol, the study incorporates a PRISMA-based workflow diagram to visually present the identification, screening, and inclusion stages as represented by Table 2 as well as in Figure 1 also. This enhances transparency and ensures methodological replicability in line with best practices in systematic review reporting.

4 | Results

4.1 | Life Cycle of Scientific Production

The bibliometric analysis reveals a clear evolutionary pattern in AI–entrepreneurship research. The first publications were few, until around 2015, when there was a sudden rise, which is associated with the growing integration of AI technologies in the entrepreneurial practice. As Figure 2 shows, the rate of growth has increased dramatically after 2020, which has heralded a period of high academic activity due to a combination of converging forces. Interestingly, the general prevalence of AI in startup and small-business frameworks, the broad acceptance of generative AI systems, and the increased institutional and policy interest have all played a big part in this trend [25, 42]. Furthermore, the COVID19 pandemic acted as a significant source of acceleration, driving the digitalization of business ecosystems, and forcing entrepreneurial activities to embrace AI-based solutions to stay flexible and robust enough to prompt additional scholarly attention and publication activity. The cumulative growth curve, which is plotted with the help of a logistic growth function, indicates the saturation point at around 245 publications, and the curve starts to flatten after 2024, indicating that the field is entering a maturity stage, where the literature base has already been formed to a large extent.

The given transition is also explained by the Life Cycle of Scientific Production module in Figure 3 that implements the logistic growth model based on the scientific paradigm and innovation diffusion theory. This method allows one to determine the stage of a research area, whether it is in the emergence, rapid-growth, maturity or decline stage hence giving some predictive intelligence on its future path. In particular, the logistic growth

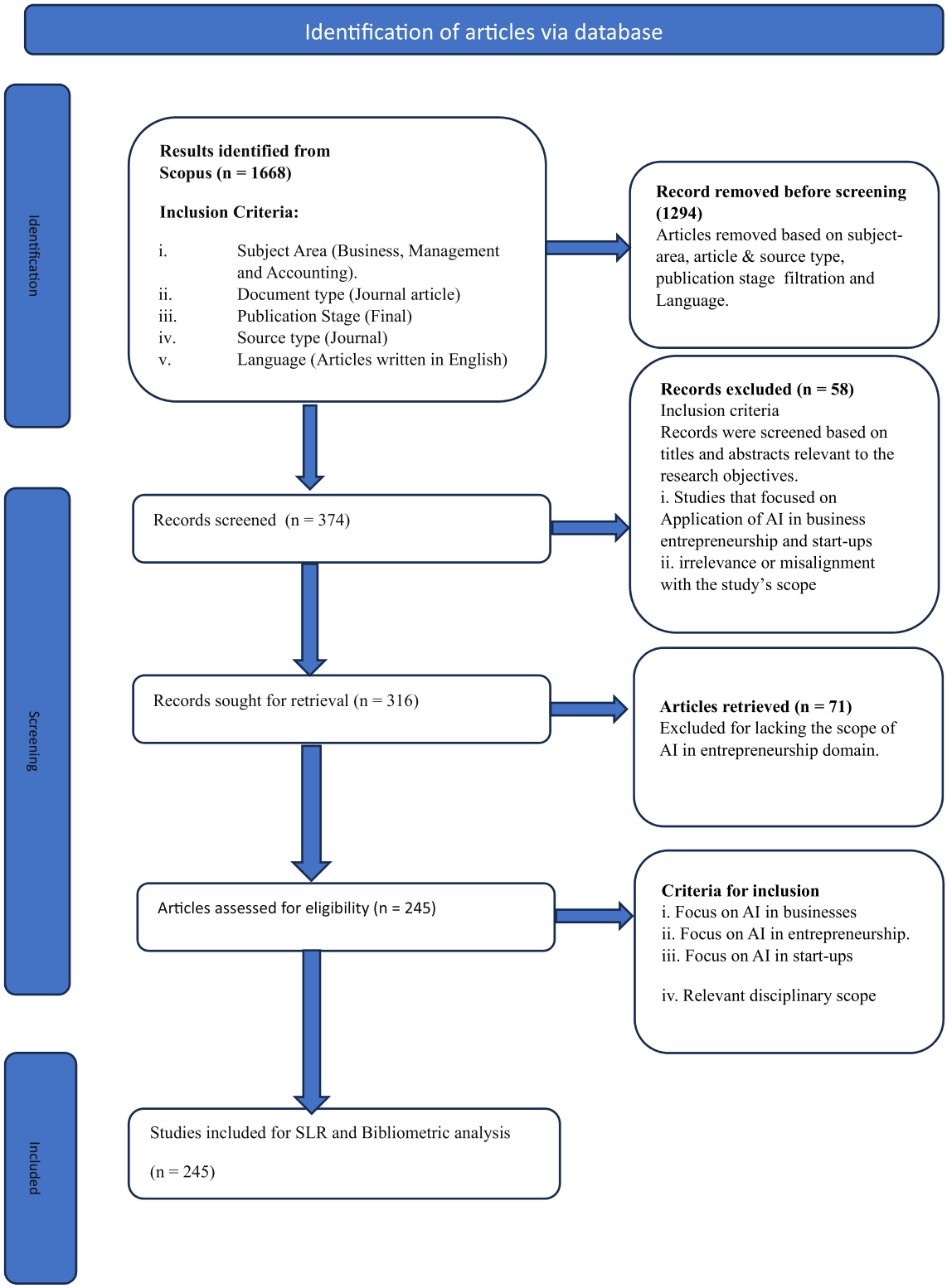

FIGURE 1 | Prisma model.

function, which can be formulated as $P(t) = K/(1 + \exp.(-b(t-t_0)))$, is used to describe the dynamics of cumulative publications throughout the years and provides a data-driven prism through which the stages of the evolution of the field can be evaluated. In addition, the annual life-cycle curve depicts that the scholarly production was the highest in 2024 (79 publications), which is also backed by a good logistic model fit ($R^2 = 0.788$).

But an anticipated drop in output per year after this period indicates a transition to less innovative and more exploratory research to a more consolidated stage of refining theories, achieving methodological rigor, and practical influence. This kind of shift is characteristic of interdisciplinary areas that shift between conceptual growth to applied contraction. At this maturing stage, researchers are concentrating more on practical

TABLE 2 | Inclusion/exclusion criteria.

Criteria type	Included studies	Excluded studies
Core focus	Explicit focus on AI/artificial intelligence	Purely technical or algorithmic studies with no business relevance
Contextual setting	Set within business, entrepreneurship, or start-up ecosystems	Studies centered only on large, established organizations (non-entrepreneurial)
Scholarly contribution	Offers conceptual, empirical, or methodological insights into AI's role in entrepreneurship	Editorials, opinion pieces, or non-scholarly content

Source: Authors' development.

FIGURE 2 | Annual publication trend and mean citation per article.

issues, ethical issues, and sustainability questions of AI in entrepreneurial ecosystems [43]. The value of such findings is that they allow mapping the present position of the field in the scientific life cycle, indicating that it is at a critical inflection of its life cycle (see Figure 3). Due to the advances in the field, future research should focus on the empirical richness, interdisciplinary synthesis, and practical implementation to facilitate the adoption of AI in an entrepreneurial and business environment in a robust, responsibly, and scalable way. Such understandings are essential in future research agenda, funding priorities, and the evidence-based policy formulation in the nexus of technology and entrepreneurship.

4.2 | Trending Articles

Table 3 shows the 10 most impactful articles in the subject of artificial intelligence and digital entrepreneurship by the total number of citations, with additional citation-normalized indicators. The review shows that there is a strong focus on the most significant studies that were conducted in 2018–2023, so the rapid maturation of this research stream may be assessed. The articles published in Technological Forecasting and Social Change take up the first position in the ranking, thus validating the journal as a primary publication medium. High quotas of citation in a year and normalized quotas of citation also demonstrate a long-standing scholarly topicality and cross-disciplinary impact, especially in the field of the literature of entrepreneurship, innovation, and digital transformation.

4.3 | Most Prolific Journals

Table 4 shows the most prolific journals in terms of volume of publication and quality measures with regards to research that is located at the intersection of artificial intelligence, entrepreneurship, and business. The most prominent outlet is the Technological Forecasting and Social Change, which has the most articles [13], and a strong Scopus CiteScore, a Q1 position, and an A—category ranking in the ABDC list; all of that contributes to the idea of its central role in the field. Other well-regarded Q1 journals such as the Journal of Business Research, International Entrepreneurship and Management Journal and European Journal of Innovation Management continue to demonstrate the high rate of well-established management and entrepreneurship journals. The prevalence of the reputable publishing houses, including Elsevier, Emerald, Springer, and MDPI, indicates a large global distribution and academic reliability. Generally, the spread of the research shows that the literature in this area is focused on high-impact, internationally recognised journals, which supports the academic rigor of the literature and the maturity of it.

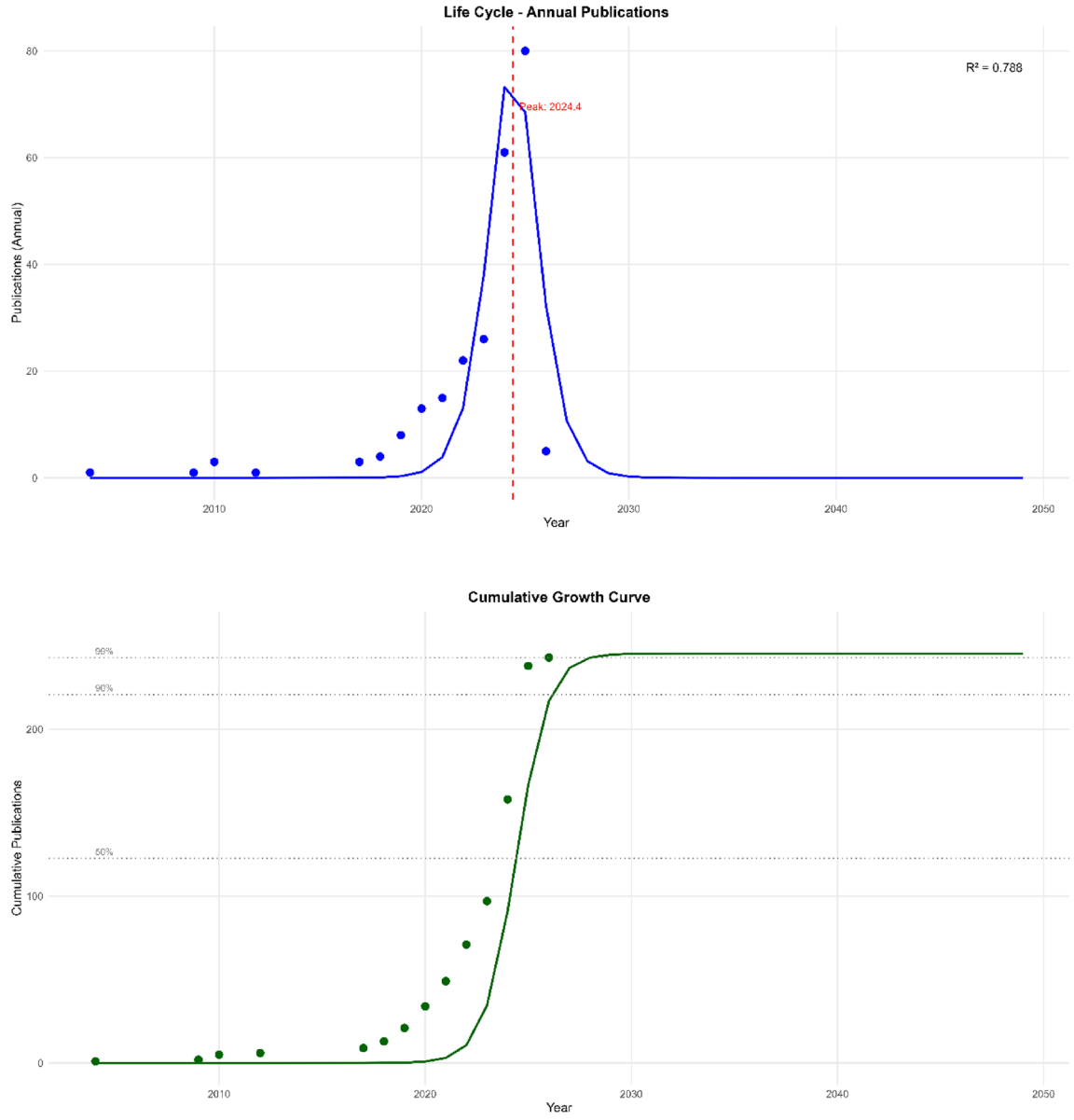

FIGURE 3 | Life cycle of scientific production.

4.4 | Most Contributing Authors

Table 5 outlines those authors with the most significant contributions to the field, which includes productivity (TP), domain relevance (DRP), citation impact (TC), institutional affiliation, and geographical dispersion. B. B. Gupta of Asia University, Taiwan (Asia-Pacific) is the most prolific with 795 total publications, 3 domain related publications and 25,633 citations and a high Scopus h-index of 83 indicates outstanding scholarly impact. Alexander Michael Brem of Universität Stuttgart, Germany (Europe), comes in second (284 publications, 2 domain relevant works, 10,347 citations, h-index = 53). The Asian, European, North American, and Middle Eastern presence of authors points to the global and collaborative character of the research in this field and sustained effects are indicated by good TP-DRP ratios and citation performance.

4.5 | Most Productive Versus Most Cited Countries

Table 6 provides a comparative summary of the most productive and most cited countries, thus explaining a sharp dichotomy of the volume of publications and the impact on citation. Although India leads in publication volume, its relatively low citation impact suggests a need for greater theoretical consolidation and international collaboration to enhance scholarly influence. As contrasted to that, Italy, which has been ranked fifth in productivity, has the highest citation influence, with 1544 total citations and average article citations, thus indicating a high quality of research and international visibility. The United States and the United Kingdom are in the middle ground, with both countries being ranked highly in terms of productivity and citations. On the whole, the comparison shows that the increased volume of publications does not always lead to increased scholarly influence, which is why the

TABLE 3 | Most trending articles.

Rank	Author	Article	Journal	Total citations	TC per year	Normalized TC
1	[44]	Digital entrepreneurship ecosystem: How digital technologies and collective intelligence are reshaping the entrepreneurial process	Technological Forecasting and Social Change	771	110.14	5.13
2	[45]	Digital transformation challenges: strategies emerging from a multi-stakeholder approach	The TQM Journal	368	52.57	2.45
3	[46]	Human capital and AI in industry 4.0. Convergence and divergence in social entrepreneurship in Russia	Journal of Intellectual Capital	317	45.29	2.11
4	[47]	How should we understand the digital economy in Asia? Critical assessment and research agenda	Electronic Commerce Research and Applications	281	40.14	1.87
5	[48]	Artificial Intelligence as a Growth Engine for Health Care Startups: Emerging Business Models	California Management Review	214	26.75	3.70
6	[13]	Machines augmenting entrepreneurs: Opportunities (and threats) at the Nexus of artificial intelligence and entrepreneurship	Journal of Business Venturing	139	27.80	5.12
7	[49]	Analysis of artificial intelligence-based technologies and approaches on sustainable entrepreneurship	Technological Forecasting and Social Change	136	34.00	3.77
8	[50]	Innovation Analytics and Digital Innovation Experimentation: The Rise of Research-driven Online Review Platforms	Technological Forecasting and Social Change	133	22.17	3.97
9	[51]	Digitalization of work and entry into entrepreneurship	Journal of Business Research	126	21.00	3.76
10	[52]	The influence of digital entrepreneurship and entrepreneurial orientation on intention of family businesses to adopt artificial intelligence: examining the mediating role of business innovativeness	International Journal of Entrepreneurial Behavior & Research	119	29.75	3.29

Source: Authors' development.

quality of research, its visibility, and collaboration on the international level are essential.

The analysis of the heat-map by Figure 4 shows that there is a significant difference between research productivity and the citation impact of different countries. In terms of the number of publications published, India is the most fruitful country, followed by the United States, China, and the United Kingdom, implying a slightly more global coverage of the research output. On the contrary, there is a different trend in

TABLE 4 | Most prolific journals.

Journal	Publisher	Journal origin	Scopus citescore	Scopus quartile	ABDC category	Articles
Technological Forecasting and Social Change	Elsevier	1969	26.3	Q-1	A	13
Emerald Emerging Markets Case Studies	Emerald Publishing	2011	0.4	Q-4	NA	8
Administrative Sciences	MDPI	2011	5.6	Q-1	NA	6
International Entrepreneurship and Management Journal	Springer	2005	10.7	Q-1	C	5
International Journal of Management Education	Elsevier	2000	13.7	Q-1	C	5
Journal of Business Research	Elsevier	1973	25.3	Q-1	A	5
Journal of Entrepreneurship in Emerging Economies	Emerald Publishing	2013	8.1	Q-1	C	5
Cogent Business and Management	Cogent OA	2015	4.9	Q-1	NA	4
European Journal of Innovation Management	Emerald Publishing	1998	12.3	Q-1	C	4
International Journal of Entrepreneurial Behaviour and Research	Emerald Publishing	1995	9.3	Q-1	B	4

Source: Authors' development.

the citation map where Italy shows significantly high number of citations even though it does not lead in the number of publications showing a stronger influence and impact of research. The United Kingdom, United States, and China also exhibit great performance of citing whereas there are highly productive countries with rather lower citation intensity. On the whole, the results suggest that an increase in the volume of publication does not always lead to an increase in scholarly impact, and research influence seems to be more dispersed among a smaller number of countries than research productivity.

4.6 | Thematic Analysis

Figure 5 highlights the thematic structure of the literature in terms of centrality and density, dividing the themes into motor, basic, niche and emerging or declining quadrants. The dominance of AI and entrepreneurship in the motor quadrant indicates theoretical consolidation, suggesting that the field is transitioning from exploratory fragmentation toward conceptual maturity. The motor themes include artificial intelligence, entrepreneurship, generative AI, and digital transformation, which means that well-established and highly central research streams are actively used to push the intellectual core of the field through the strong conceptual synthesis and scholarly applicability. The fundamental themes, such as innovation, digital entrepreneurship, and business model innovation, reflect pillars of the foundational nature, as they are quite relevant though with a relatively less developed internal development, which implies the possibility of further theoretical consolidation. The niche themes, like machine learning, decision-making, human resources management, technology, e-learning and investments, represent narrow and mature sub-domains that have few cross-linkages to the overall research framework. Lastly, the new or waning ones, such as AI and IoT convergence and COVID-19-related business education, are the focal points of the new technological intersections or context-related research reactions. On balance, the thematic map demonstrates the definite shift of the standalone, technology-centered research to the combined, AI-enabled, entrepreneurial, and innovation-oriented research directions.

4.7 | Bibliographic Coupling Analysis

Figure 6 shows the bibliographic coupling network based on the affiliation of first authors to countries, thus showing the intellectual frame and geographic spread of research outputs. The visualization discovers four salient clusters, each with common reference trends and thematic closeness between nations. The blue cluster, which is based in the United States and has close associations with France, Spain, Portugal, Sweden, and Canada, is a very powerful and networked research centre, which means that it is at the centre of determining the intellectual foundations of the field. The green cluster, which consists mainly of China and is closely related to the economies of Indonesia, Malaysia, and Vietnam, indicates the increasing role of Asian economies as active participants, which means that some of the emerging research agendas are concentrated in the region, and more of them are collaborating in Asia. The group of red colour, headed by India and Saudi Arabia, and the Jordan being a node closely connected to it, shows a different line of scholarship which is coming out of

TABLE 5 | Most contributing authors.

Rank	Author	Affiliation	ORCID	Scopus *h*-index	TP/DRP	TC
1	B. B. Gupta	Asia University, Taichung, Taiwan	0000-0003-4929-4698	83	795/3	25,633
2	Alexander Michael Brem	Universität Stuttgart, Stuttgart, Germany	0000-0002-6901-7498	53	284/2	10,347
3	Akshat Gaurav	Asia University, Taichung, Taiwan	0000-0002-5796-9424	22	181/2	1589
4	Aleksy Kwilinski	WSB University, Dabrowa Gornicza, Dabrowa Gornicza, Polan	0000-0001-6318-4001	58	141/2	6491
5	Hamid Etemad	Université McGill, Montreal, Canada	NA	20	114/2	1736
6	Tomas Kliestik	University of Žilinab, Zilina, Slovakia	0000-0002-3815-5409	35	106/2	4001
7	Eugenio M. Fedriani	Universidad Pablo de Olavide, de Sevilla, Sevilla, Spain	0000-0002-1707-3308	7	37/2	205
8	Samer Abaddi	IDentity Research, Amman, Jordan	0000-0003-4612-7384	6	18/02	164
9	Sandro Battisti	Bruno Kessler Foundation, Trento, Italy	0000-0002-7818-1230	7	13/2	119
10	Manuel Chaves-Maza	Universidad Pablo de Olavide, de Sevilla, Sevilla, Spain	0000-0003-2420-8378	3	9/2	45

Abbreviations: DRP, domain related publication; TC, total citations; TP, total publications.
Source: Authors' development.

TABLE 6 | Most productive versus most cited countries.

Most productive countries			Most cited countries			
Rank	Country	TP	Rank	Country	TC	Average article citations
1	India	72	1	Italy	1544	110.3
2	United States of America	46	2	United Kingdom	472	33.7
3	China	40	3	United States of America	461	38.4
4	United Kingdom	38	4	China	411	24.2
5	Italy	32	5	Australia	234	78
6	Indonesia	25	6	India	165	5.9
7	South Korea	23	7	Indonesia	135	15
8	Ukraine	23	8	Germany	130	32.5
9	Saudi Arabia	18	9	Finland	119	29.8
10	Spain	17	10	Ukraine	116	38.7

Source: Authors' development.

obscurity and showing high levels of coherence in the region, especially in South Asia and the Middle East. In the meantime, the yellow and purple clusters, which include Germany, Italy, Denmark, the United Arab Emirates, Slovakia, and Ukraine, represent the fact that Europe remains an intellectual leader and bridges between clusters. All in all, the network suggests that, although the research area is highly internationalised and has a high level of cross-continental knowledge sharing,

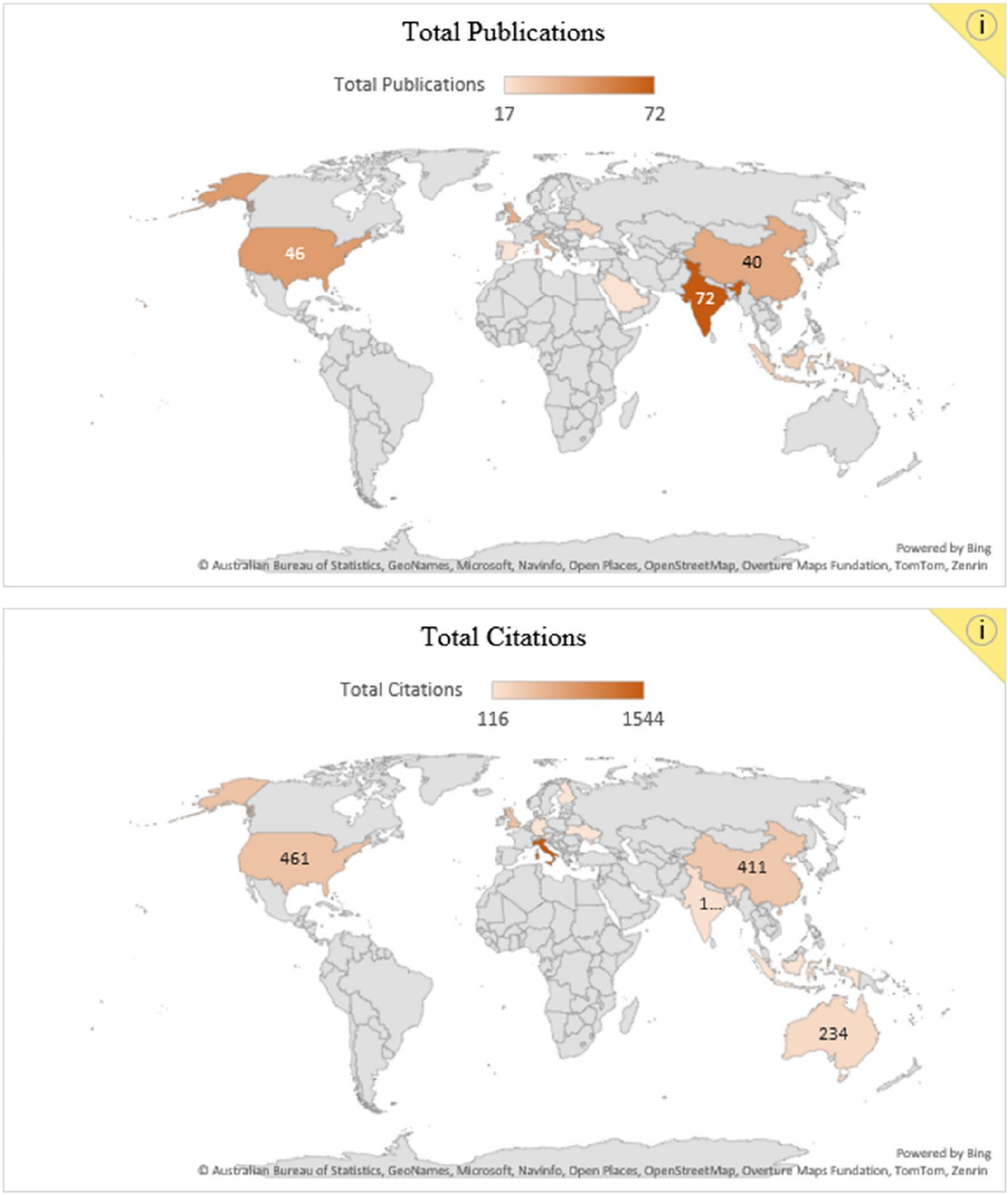

FIGURE 4 | Heat map for most productive and most cited countries. *Source:* Authors' development.

scholarly authority is still concentrated in small number of developed and fast-growing locales. The comparative lack of penetration of certain developing nations implies that there would continue to be research gaps on the capacity and access to funding and high-end digital and analytical resources and thus the more inclusive presence of the global research in the future.

4.8 | Authors' Keywords Co-Occurrence Analysis

Figure 7 illustrates a keyword co-occurrence network created using the keywords of the authors, thus defining the main thematic structure and developmental research lines in the discipline. The use of the minimum frequency threshold of three helped to keep the keywords that occurred more often and increase the rigor of the analysis and prevent the impact of rare words. The sizes of nodes are proportional to the frequency of keywords and the strength of links represents the strength of conceptual relationships. The main intellectual core of the field is the red central cluster, which is controlled by artificial intelligence and is closely connected with entrepreneurship, machine learning, and big data. This group of clusters suggests that modern studies highly focus on AI as a defining technology that influences the process of entrepreneurship, decision-making, and the results of innovations.

FIGURE 5 | Thematic map. *Source:* Authors' development.

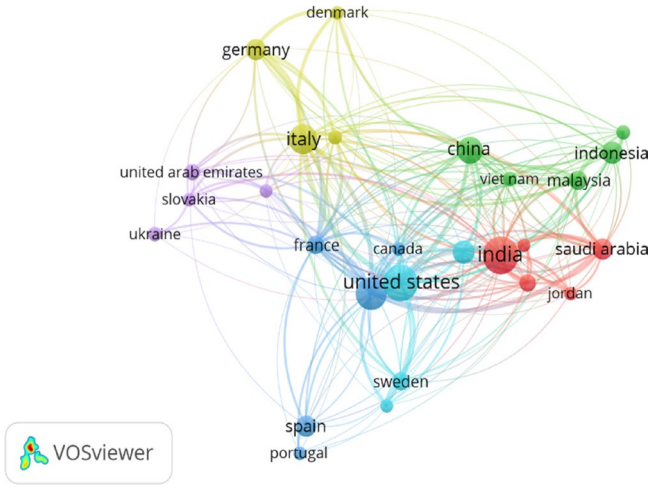

FIGURE 6 | Bibliographic coupling analysis—country of affiliation.

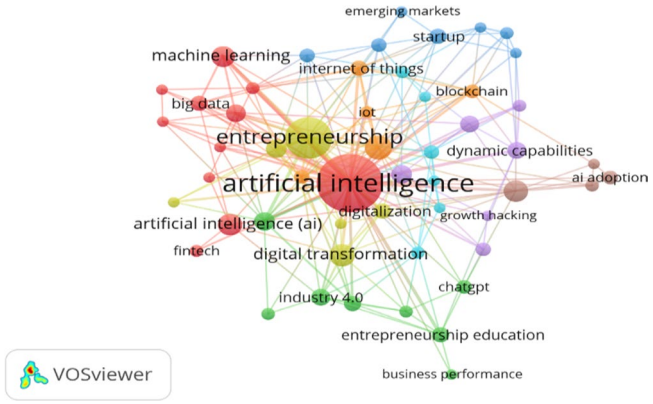

FIGURE 7 | Co-occurrence analysis.

The fact that machine learning and big data are closely related reflects the analytical and data-driven focus of AI-enabled entrepreneurship studies.

The yellow cluster that is rooted in the constructs of digital transformation and digitalization is a conduit that links the technological capabilities and organizational change. Strong ties with artificial intelligence and entrepreneurship would mean that digital transformation is a key process by which AI-based technologies can be implemented in the context of entrepreneurship and business. The green cluster, which includes Industry 4.0, entrepreneurship education, business performance, and newer terms, such as ChatGPT, is indicative of a shift towards applied and pedagogical aspects of AI and entrepreneurship. The ChatGPT inclusion refers to the new dawn of generative AI tools as a potential research future.

The blue cluster, which is organized around nascent businesses, emerging markets, and the Internet of Things, predicts the studies of the facilitative nature of advanced digital technologies in the creation of ventures, particularly in dynamic, resource-constrained milieus. The given observation indicates the growing academic curiosity towards the context-sensitive, market-oriented implementations of AI-enhanced technologies. The dynamic capabilities, growth hacking, and adoption of AI cluster under the purple and brown clusters, which look forward to the strategic and managerial perspectives. These groups highlight the questions that researchers pose regarding how firms develop adaptive capabilities and develop adoption strategies to make use of AI to gain competitive advantage and scalable growth.

The network clarifies a very entangled, interdisciplinary research environment, artificial intelligence and entrepreneurship have a central nexus. The high levels of connectivity between clusters can be interpreted as indicative of thematic convergence whereby, technological, strategic, educational, and performance-based orientations interact to shape the emerging scholarly discussion. This trend indicates the growing research field at the same time as it tracks new strands (primarily generative AI and capability-driven entrepreneurship), which are prospective fertile areas of future research.

TABLE 7 | Applications of AI in entrepreneurship.

Cluster domain	Common keywords	Representative applications
Marketing and customer engagement	Digital marketing, social media, customer analytics, chatbots, growth hacking	Chatbots for customer service; AI-driven customer segmentation and personalized marketing campaigns
Finance and funding	Crowdfunding, fintech, financial management, predictive Modeling, investment	ML models predicting crowdfunding success; AI tools for SME financial risk analysis (LLM-based diagnostics)
Product development and innovation	Innovation, idea generation, algorithmic creativity, prototyping, design	Generative AI for brainstorming new product ideas; AI-assisted rapid prototyping and design optimization
Decision-making and strategy	Data-driven decisions, opportunity recognition, strategic planning, analytics	AI analytics for market trend identification; decision support systems guiding strategic venture decisions
Entrepreneurship education	Entrepreneurship education, e-learning, training, student entrepreneurs, knowledge	AI-driven platforms for entrepreneurship training; virtual assistants providing feedback in venture simulations
Operations and performance	Productivity, dynamic capabilities, efficiency, HR management, scaling	Automation of routine operations; AI systems enhancing employee productivity and adaptive business processes

4.9 | AI Application in Entrepreneurship

In Table 7, the bibliometric analysis shows that the field of artificial intelligence is being more operationalized in various functional areas of entrepreneurship, which is an indicator of the shift in theoretical exposition to empirically based, practice-based research. One of the salient areas of application is in the field of marketing and customer interaction, where AI-based analytics, machine learning, and big-data platforms can enable young companies to improve customer segmentation and customization, as well as use growth-hacking strategies. These affordances support the data-driven decision-making and scalable customer acquisition, especially in digital, platform-based ecosystems. To explore the topic of AI-based marketing in-depth and the direction of future research, refer to [11]. The other application area is especially critical in relation to innovation and product development, where AI supports the identification of opportunities, ideation, and quick prototyping. The generative AI products are increasing the speed at which people create works and reducing the time taken to innovate, making companies able to react to the market needs in a timely manner. AI is also widely used in the strategic decision-making process, where entrepreneurs use predictive analytics and real-time data insights to forecast the market, allocate resources, and position in the market.

The corpus also sheds light on the use in the finance and operations industry, including FinTech applications, automated financial analytics, and performance optimization systems to enhance efficacy and reduce uncertainty in new projects. There are new uses that can be identified in the field of entrepreneurship education and developing capabilities, where AI-enhanced learning platforms, simulations, and applications like ChatGPT can help learn skills and gain experience. Together, these instantiations depict that AI is a transformational enabler in the entrepreneurial field, where it regulates innovation, performance, and scalability in diverse heterogeneous settings.

5 | Conclusion

The presented systematic literature review and bibliometric analysis offered a significant contribution to the theoretically and practically focused interpretation of artificial intelligence (AI) applications in business entrepreneurship and start-ups as it will synthesize and organize a rapidly growing but disjointed body of knowledge. Based on the SPAR-4-SLR protocol, the research combines performance analysis with science-mapping methods in an attempt to demonstrate the evolution of the field, the intellectual underpinnings, and patterns of application in a clear and reproducible procedure.

According to the results, there is a strong increase in the rate of scholarly production after 2018 and especially after 2020, as the integration of AI into entrepreneurial ecosystems continues to grow, and the research agenda shifts to the implementation and impact results. Co-citation, thematic mapping, bibliographic coupling, and keyword co-occurrence analyses all point to the prevalent research directions that include AI-enabled entrepreneurship, digital transformation, innovation and business model development, and capability-building in Industry 4.0 settings, and new trends of generative AI tools such as ChatGPT. One of the most important findings of this research is the ability to unify these streams into a logical thematic framework and associate them with application areas like marketing and customer engagement, product development and innovation, decision-making and strategy, finance and funding, entrepreneurship education, and operations and performance to enhance the clarity of the theoretical understanding of AI as both a technological artifact and a strategic

resource that influences the opportunity recognition, experimentation, and venture scalability.

In addition to domain mapping, the review finds that there are significant gaps in the field of insufficient empirical validation, excessive use of cross-sectional methods, and inadequate consideration of contextual diversity, especially in emerging markets and start-up environments with limited resources, thus promoting future research to take longitudinal and mixed-method designs, explore more in-depth human-AI collaboration mechanisms, and focus on responsible AI adoption, ethics, and governance in start-ups.

The limitations of the study are that it is based on a single database and bibliometric tools and that the completeness of Scopus metadata is used, and future studies can expand the scope to other databases, interdisciplinary prism and more methodological triangulation, which offers a unified basis and roadmap to the future in supporting rigorous, responsible and application-driven scholarship where AI, entrepreneurship, and start-up ecosystems meet.

5.1 | Future Research Direction

Although the body of work concerning AI-enabled entrepreneurship is growing swiftly, a number of conceptual, methodological, and contextual gaps remain, which warrant the use of viable research opportunities. The main weakness of preliminary research is that it has mostly cross-sectional designs and uses secondary data which restricts causal conclusions and makes it impossible to capture the evolution of ventures over time. Future studies, therefore, should consider longitudinal and mixed-method research designs to explore the role of AI capabilities in recognizing opportunities, orchestrating resources, and performance of a venture at different stages of growth [2, 37].

Another opportunity direction is to go beyond a technology-centric approach to AI and adopt a socio-technical and capability-based approach. Previous academic work often represents the adoption of AI as a dichotomous or homogenous phenomenon, thus ignoring the differences in the maturity of AI, the quality of data, and human-AI interaction. Further research needs to investigate the micro-level processes, including the founder cognition, AI literacy, and ethical awareness, and their relationships with organizational culture and governance systems [32, 53]. Contextual constraints can also be seen, with much of the available evidence being based in developed economic entities and in technology-based industries. The emergence of AI-based venture creation is also in need of comparative and emerging-economy studies to clarify how institutional voids, regulatory uncertainty, and resource limitations influence AI-driven venture creation, especially in MSMEs and start-ups [14, 54]. The industry-related studies such as AI-based marketing, fintech, healthcare, and sustainability-focused projects can further narrow down theory and practice to examine the concept of AI-based marketing in-depth and the future directions of the research.

The ethical, legal, and societal implications are the areas that should be covered in future research, as they remained virtually unexplored in previous studies. Algorithms bias, data privacy, accountability, and responsible AI governance are issues that should be subjected to systematic empirical research, particularly when applied to venture decision-making processes and scaling [55, 56]. The combination of the entrepreneurship theory, AI ethics, and public policy may, therefore, promote a more comprehensive and accountable vision of AI-powered business and venture creation.

5.2 | Theoretical Implications

This paper makes a valuable addition to the growing body of literature on the topic of artificial intelligence (AI) and entrepreneurship by integrating fragmented research findings in a synthesized methodology of literature review and bibliometric analysis. The investigation is also more effective in shedding light on the intellectual structure and knowledge base that AI-enabled entrepreneurship research relies on, which is considered to be especially effective when mapping the boundaries of research and developing new thematic clusters [40, 57]. Unlike the form of earlier reviews, which mostly utilized narrative synthesis or citation-counting tools, the present study provides a more accurate representation of thematic clusters, conceptual correlations and stream of research of practical use. The recognition of the overarching themes, such as AI-driven innovation, digital transformation, startups, and capability building, makes the development of the theory possible as it clarifies how AI is not a technology but a strategic entrepreneurial tool. Moreover, the research offers a basis to future theoretical frameworks, where scholars should move beyond descriptive studies to integrative frameworks that are able to relate AI adoption, entrepreneurial capabilities and venture outcomes.

5.3 | Managerial Implications

Organizational wise, the results provide practical information among entrepreneurs, startup managers, policymakers, and ecosystem stakeholders. The subtle knowledge about the thematic structure of AI applications allows entrepreneurs to strategically implement AI in areas such as marketing analytics, innovation processes, financial decision-making, and operational efficiency. These insights can be used by policymakers and ecosystem enablers to formulate enabling policies, training opportunities, and AI-friendly entrepreneurial systems, especially in the emerging economies. Besides, teachers and managers of incubators can use the described applications to introduce AI-powered methods to the field of entrepreneurship education and venture support systems to develop a data-driven and innovation-focused mentality. On the whole, the research encourages prudent decision-making and accountable adoption of AI, thus sustainably and scalable developing entrepreneurship.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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