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Review Article

Mapping the Intellectual Core of Technology Adoption in Digital Startups: A Bibliometric Analysis via Bibliographic Coupling and Co-Word Networks

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Abstract

Digital startups are reshaping markets through the use of AI, cloud computing, and blockchain; however, scholarship on how these firms adopt technology remains fragmented. This study systematically maps the intellectual structure and thematic fronts of research on technology adoption in digital startups. A field-tagged Scopus search conducted in September 2025 (coverage 2000–2025) was cleaned and harmonized using a VOSviewer. After de-duplication, 2,243 documents were analyzed via bibliographic coupling (knowledge structure) and co-word analysis (thematic). Four coherent clusters emerge. Strategic innovation and leadership function as the governance backbone that shapes adoption decisions and risk appetite. Sustainable, data-driven business models translate adoption into performance outcomes through analytics capability and value capture. Corporate entrepreneurship within innovation ecosystems bridges firm-level capability with external partners, investors, and accelerators, linking adoption speed to ecosystem embeddedness. Digital business transformation operationalizes AI/cloud investments into processes and customer journeys. Cross-cutting co-word foci, such as perceived usefulness/user experience and organizational readiness, act as mechanisms connecting individual cognition with organizational capability. Emergent topics in policy, regulation, and platform governance appear as boundary conditions that enable or constrain adoption trajectories. The mapping provides an integrative lens organized along two axes: cognitive evaluation and organizational capability that jointly explain adoption in digital startups. It identifies gaps in external enablers and capability maturation paths. A forward-looking agenda is proposed, featuring multi-level models that link cognition, capability, and growth, as well as quasi-experimental evaluations of interface simplification and onboarding, cross-country comparisons of regulatory regimes, and longitudinal tracking of platform transitions.

Keywords: Bibliometric Analysis; Digital Startups; Digital Transformation; Entrepreneurial Ecosystems; Technology Adoption.

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1. INTRODUCTION

Digital startups have emerged as transformative agents in the global economy, leveraging advanced technologies to foster innovation and disrupt traditional industries. These enterprises employ a diverse range of technological solutions, including artificial intelligence (AI), machine learning (ML), cloud computing, and blockchain to develop novel business models, enhance operational efficiency, and deliver new value propositions to customers [1]–[3]. The rapid pace of technological advancement has profoundly influenced the operational dynamics of digital startups, enabling them to scale rapidly and respond to market demands with exceptional agility [4]–[8]. The adoption of such technologies is not only crucial to the growth and competitiveness of startups but also instrumental in shaping the broader digital ecosystem.

Among the various technologies adopted by digital startups, AI and automation have been extensively implemented in areas such as product development, customer service, and data analytics, resulting in heightened productivity and reduced operational costs [9]–[11]. Similarly, cloud computing has revolutionized infrastructure management by providing flexibility, scalability, and cost efficiency that were once unattainable for small and medium-sized enterprises [12], [13]. Moreover, blockchain technology has created new opportunities for secure transactions, digital currencies, and decentralized applications, positioning digital startups at the forefront of the evolving digital economy [14]–[16].

Despite the rapid diffusion of these technologies, significant gaps persist in understanding how digital startups navigate the challenges and opportunities inherent in technology adoption. The adoption process is multifaceted, influenced by factors such as technological readiness, financial capacity, market dynamics, and organizational culture [17]. Although the advantages of technological integration are widely acknowledged, limited research has examined its long-term implications for the sustainability and scalability of startups. Additionally, the interaction between technology adoption and strategic decision-making remains underexplored, particularly within emerging markets and diverse cultural contexts [18], [19].

To address these gaps, the present study employs bibliometric mapping to provide a comprehensive overview of the existing literature on technology adoption in digital startups. Unlike prior studies that focus narrowly on specific technological applications or isolated case studies, this research synthesizes broader trends, interdisciplinary collaborations, and emerging research clusters within the field. By identifying the key technologies adopted by digital startups, the challenges encountered during adoption, and the evolving strategic role of technology, this study seeks to fill existing knowledge gaps and offer deeper insights into how technological adoption drives the growth and success of digital startups [20], [21].

Through bibliometric analysis, this research not only evaluates the current state of the field but also delineates future research directions that can bridge existing gaps. These directions include examining the relationship between technology adoption and innovation capacity, assessing the influence of external factors such as government policy, and exploring cross-industry collaborations as catalysts for technological advancement [22], [23]. Ultimately, this study aims to serve as a critical reference for scholars, entrepreneurs, and policymakers seeking to optimize technology adoption strategies in digital startups, thereby contributing to the development of a sustainable and innovative digital economy.

Two primary research objectives guide this study. First, it seeks to identify the current and emerging research streams in the field of technology adoption within digital startups through bibliographic coupling analysis. This objective aims to map the intellectual structure of existing studies and reveal the major thematic areas that have shaped scholarly discourse on this topic. Second, the study seeks to assess future research trends and directions using a co-word analysis approach, which facilitates the identification of emerging themes, conceptual linkages, and potential areas for future exploration in the domain of digital startup technology adoption.

2. LITERATURE REVIEW

Bibliometric mapping of technology adoption in digital startups has become a central theme in the study of digital entrepreneurship. Recent research indicates a marked rise in scholarly interest in this area, particularly since the early 2000s. For instance, a bibliometric analysis by Greven et al. [24] highlights a rapid surge in publications addressing digital entrepreneurship, with a focus on digital ecosystems, technology integration, and entrepreneurial behavior. Similarly, Hadizadeh et al. [14] emphasizes the growing significance of digital platforms, innovation, and e-commerce within the context of digital startups. This growing body of literature highlights how the adoption of technology has evolved into a crucial determinant of the success and sustainability of digital startups. Collectively, these studies reveal recurring thematic patterns that span innovation ecosystems, organizational capabilities, and the dynamics of digital business models; yet, few provide a comprehensive, macro-level synthesis that integrates these themes cohesively.

Technology adoption remains a key factor influencing the performance and survival of digital startups. Models such as the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT) are frequently employed to explain technology adoption decisions [25]–[28]. Although these models have been widely applied across diverse sectors, their application in the context of digital startups remains limited and warrants deeper investigation. Future research could explore how factors such as perceived ease of use, perceived usefulness, and the alignment of technology with business objectives shape adoption decisions in startup environments. From a macro-bibliometric perspective, core TAM constructs, such as perceived usefulness and perceived ease of use, and UTAUT constructs, including performance expectancy, effort expectancy, social influence, and facilitating conditions, are implicitly represented in keyword clusters associated with "user experience," "organizational readiness," and "digital capability." However, these constructs are seldom explicitly articulated as the theoretical foundation of the field. In other words, while numerous studies map thematic structures through co-word analysis or topic modeling, few examine how TAM and UTAUT constructs underpin inter-theme relationships across the research corpus.

Furthermore, studies such as Seno Wulung et al. [29] and Srivastava et al. [30] identify innovation and organizational resilience as pivotal determinants of startup success. Their bibliometric analyses emphasize how the adoption of digital technologies enhances innovation capacity and organizational adaptability, enabling startups to withstand market volatility and competitive pressures. This evidence reinforces the notion that technology adoption is not merely a driver of process efficiency, but also a strategic lever for competitiveness and long-term survival. Nevertheless, prior research has often centered on specific technologies (e.g., artificial intelligence or data analytics) or confined its focus to particular regions or industries. As a result, the temporal evolution of research themes for instance, the transition from "e-commerce enablement" to "platform orchestration" and "AI-enabled decision-making" has not been systematically captured. Moreover, external dimensions, including government policy, data regulation, and market conditions, frequently appear as peripheral keywords but are rarely conceptualized as systemic enablers linking intention, adoption, and value creation in startup ecosystems.

Bibliometric mapping offers critical insights into the trends, challenges, and opportunities that shape technology adoption in digital startups. Although previous studies have examined various adoption factors, further research is needed to integrate existing theoretical models and contextualize them within the distinct dynamics of digital entrepreneurship. A more comprehensive framework is essential to guide startups in designing effective and sustainable technology strategies. Based on the synthesis above, three significant research gaps are identified: (1) the limited integration of TAM and UTAUT constructs at the macro level to explain the intellectual structure of the field; (2) insufficient longitudinal tracking of thematic evolution to capture shifting research frontiers; and (3) inadequate theorization of external enablers such as policy, regulation, and market conditions that shape adoption outcomes within startup ecosystems. In response to these gaps, the present study positions TAM and UTAUT as conceptual lenses for labeling and interpreting clusters derived from bibliographic coupling analysis and employs temporal co-word mapping to articulate a more refined, literature-driven research agenda tailored to the digital startup context.

3. MATERIALS AND METHODS

3.1. Research Design

This study employs a quantitative bibliometric research design to systematically analyze the evolution and intellectual structure of scholarship on digital entrepreneurship and technology adoption. The design incorporates performance analysis, including annual publication and citation trajectories, as well as the identification of prolific authors, sources, and institutions, utilizing science-mapping techniques such as co-authorship, co-citation, bibliographic coupling, and keyword co-occurrence analysis. These techniques have been widely validated in bibliometric research for uncovering thematic clusters and structural linkages within disciplines [31]–[33]. This integrative approach enables the identification of thematic clusters, collaboration networks, and temporal research shifts**,** as demonstrated in recent bibliometric mappings across fields such as sustainable performance [34], neuromarketing [35], and Industry 5.0 [36]. To ensure objectivity, transparency, and replicability**,** the study utilizes standardized bibliometric indicators and a fully documented analytical workflow encompassing the search strategy, export fields, data-cleaning procedures, and software parameters, an approach consistent with best practices outlined in bibliometric methodology research [37], [38].

3.2. Bibliometric Approach

The bibliometric approach provides a quantitative means of analyzing bibliographic records to reveal underlying patterns in scientific communication. In this study, three complementary techniques were employed: (i) Co-authorship analysis, which maps patterns of collaboration among authors and institutions; (ii) Co-citation analysis, which identifies influential works and delineates major intellectual traditions; and (iii) Co-word (keyword co-occurrence) analysis, which uncovers thematic structures and emerging research fronts within the field.

The analyses were conducted using VOSviewer (version 1.6.20), which facilitated the construction, normalization, clustering, and visualization of the network. Threshold parameters (minimum occurrence counts) were iteratively optimized to ensure an appropriate balance between network coverage and interpretability. To minimize potential size-related distortions, fractional counting was applied where applicable [39]. This multi-technique bibliometric framework provides a comprehensive understanding of both the intellectual landscape and the evolving research dynamics of the selected domain, aligning with established bibliometric practices in recent studies [40]–[42].

3.3. Data Source Identification

Scopus was selected as the exclusive data source due to its broad, multidisciplinary scope, consistent indexing policies, and standardized metadata structure, which encompasses titles, authors, affiliations, abstracts, keywords, and citation data. The platform's built-in author and affiliation identifiers enhance the accuracy of attribution and reduce the risk of ambiguity in collaborative datasets [43]. Furthermore, its advanced search and export functionalities enable the efficient and systematic retrieval of bibliographic records on a large scale.

Relying on a single, reputable indexing source improves internal consistency and reduces heterogeneity that may arise from varying indexing standards across databases [44], [45]. Searches were executed in Scopus using a documented and reproducible query, with the query date recorded to ensure temporal traceability. Filters were applied to restrict the dataset to journal articles published in English.

All retrieved records were exported in CSV and RIS formats, including complete bibliographic metadata (authors, titles, abstracts, keywords, sources, publication years, document types, languages, affiliations, references, and citation counts). The exported data underwent a standardized cleaning pipeline involving de-duplication, author and affiliation disambiguation, and keyword harmonization, aligning with best practices in bibliometric data management [46]. The saved search queries, export configurations, and data cleaning procedures together form an auditable trail, ensuring transparency, reproducibility, and exact replication of the study [47].

3.4. Search Strategy and Selection Criteria

A systematic search strategy was employed to identify and retrieve publications relevant to the study's objectives. The search process was carefully designed to ensure comprehensive coverage of the literature about technology adoption, digital entrepreneurship, and innovation dynamics. The strategy utilized a combination of predefined keywords and Boolean operators to capture conceptual variations and terminological nuances across bibliographic records.

This approach enabled the inclusion of a broad yet focused range of studies addressing the intersection between digital transformation and entrepreneurial practices. Searches were executed in Scopus, selected for its robust multidisciplinary coverage and consistent indexing standards. To ensure transparency and replicability, the search protocol, including database source, search terms, period, inclusion and exclusion criteria, and analytical tools, is detailed in Table 1.

Table 1. Search Protocol for Literature

No	Components	Description	Justification
1	Database Source	Scopus	Selected for its extensive multidisciplinary coverage, high-quality metadata, and reliable indexing of peer-reviewed journals.
2	Search Keywords	("technology adoption" OR "digital startups") AND ("entrepreneurship" OR "innovation" OR "digital transformation")	Combines key terms representing both technological and entrepreneurial dimensions to ensure comprehensive coverage of the topic.
3	Search Period	2000–2025	Covers 25 years of publications to capture both foundational and emerging research trends in digital entrepreneurship and innovation.
4	Inclusion Criteria	Peer-reviewed journal articles; English-language publications; empirical or theoretical relevance to digital entrepreneurship and technology adoption.	Ensures scholarly Reliability, linguistic accessibility, and conceptual alignment with the study's objectives.
5	Exclusion Criteria	Conference papers, book reviews, non-English publications, and articles without full-text availability.	Eliminates non-scholarly or incomplete works to maintain analytical consistency and data quality.
6	Analysis Tools	VOSviewer (version 1.6.20)	Used for constructing bibliometric networks, performing co-word and co-citation analyses, and visualizing thematic structures.

The results obtained from the search were screened and filtered based on the defined inclusion and exclusion criteria. Only peer-reviewed journal articles written in English and directly relevant to the research topic were retained. The final dataset was subsequently processed for bibliometric analysis using VOSviewer, which facilitated co-authorship, co-citation, and co-word network analyses.

3.5. Search Strategy and Selection Criteria

Given the exclusive use of the Scopus database, data cleaning began with a rigorous integrity audit documenting the exact query, query date, year limits, and applied filters, followed by verification to ensure that the exported record count matched the Scopus hit count. Administrative screening retained only peer-reviewed English-language journal articles within the target years, while excluding retracted papers, editorials, and conference proceedings. De-duplication was carried out using Scopus EIDs as primary identifiers, supported by DOI checks and fuzzy matching (title, year, and first author) to eliminate redundancies and maintain dataset accuracy.

To reduce ambiguity, author and affiliation data were standardized through normalization of capitalization, punctuation, and naming variants, while countries were harmonized according to ISO codes. Core metadata fields, including year, source title, document type, language, DOI, and citation counts, were validated and normalized (e.g., lowercase DOIs, replacing empty citation cells with zeros) to ensure consistency. Keyword harmonization merged Author and Index Keywords into a unified field, standardizing case and punctuation, consolidating variants (e.g., e-commerce, artificial intelligence), and applying a curated thesaurus and stop list to unify synonyms and remove generic terms.

Reference completeness was verified (author–year–source–DOI) to improve co-citation Reliability, and documents were grouped into time slices (e.g., 2000–2009, 2010–2016, 2017–2025) for temporal analysis. The cleaned master dataset was exported with VOSviewer-ready files for co-authorship, co-citation, and keyword co-occurrence mapping, using fractional counting, association-strength normalization, and documented thresholds and clustering parameters. All procedures, including saved searches, export settings, cleaning rules, and software configurations, were meticulously logged, producing a traceable, reproducible, and standardized Scopus-based corpus ready for advanced science mapping and bibliometric visualization.

3.6. Data Analysis and Visualization

The final set of 2,243 English-language journal articles was analyzed using performance indicators and network-based science mapping. Co-authorship analysis revealed collaboration patterns among researchers and institutions, co-citation analysis identified influential works and intellectual lineages, and keyword co-occurrence analysis revealed dominant themes and emerging topics.

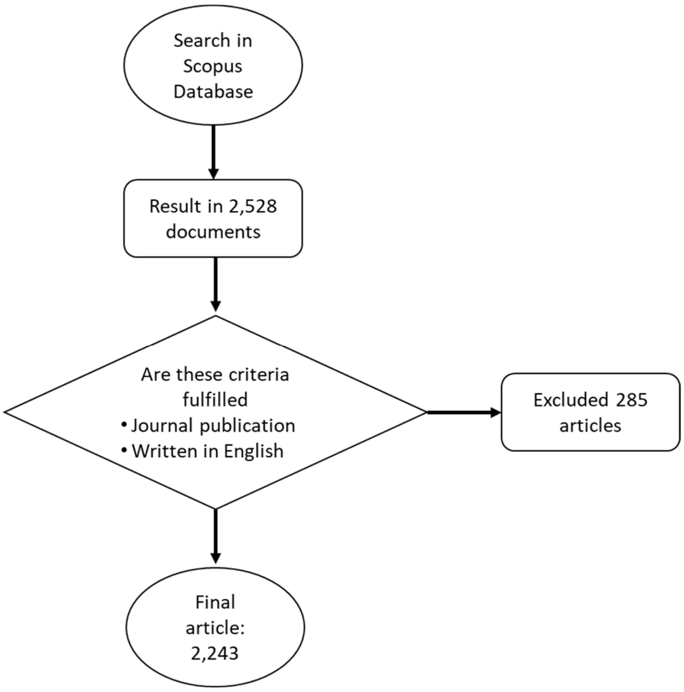

Figure 1. Flowchart of the Article Selection Process

VOSviewer network maps display clusters, link strengths, and temporal overlays, providing a visual synopsis of the field's structure and its evolution. The complete retrieval, filtering, and analysis workflow is summarized in Figure 1 (Flowchart of the article selection process), which documents each stage, from the initial search (2,528 records) to the final analytical corpus (2,243 articles).

4. RESULTS AND DISCUSSIONS

4.1. Publication and Citation Trends

A bibliometric analysis was conducted using the Scopus database, focusing on documents published between 2000 and 2025, with the search performed on September 24, 2025. The final dataset comprises 2,243 documents that have collectively received 47,751 citations, indicating a rapidly expanding and influential research field. Between 2000 and 2014, publication activity remained negligible, with fewer than 10 papers published annually. The field began to gain momentum in 2015, followed by a consistent upward trajectory in scholarly output. A pronounced surge occurred after 2016, when annual publications exceeded 50 papers and continued to accelerate each subsequent year. By 2024, the number of publications reached approximately 420–450 documents, marking the most prolific period in the dataset.

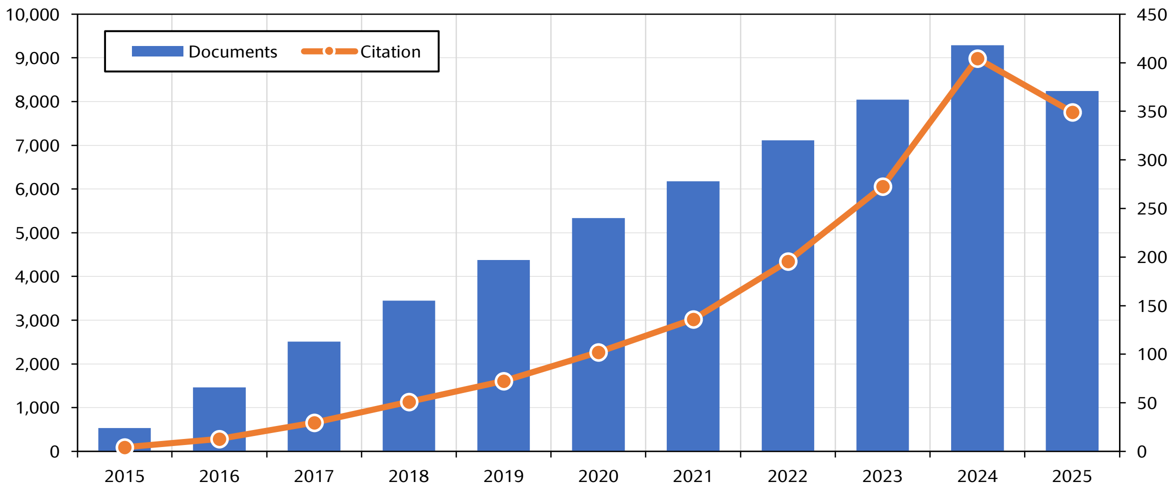

Figure 2. Number of Publications and Citations on Technology Adoption in Digital Startups (Source: Scopus.com)

Citation activity followed a similar trajectory but exhibited a clear time-lag effect, with a marked increase beginning only around 2021. Between 2021 and 2024, the total number of annual citations rose sharply from approximately 3,000 to over 11,000, reflecting both the cumulative expansion of the literature and the emergence of highly influential studies. The estimated h-index of 94 further highlights the field's strong citation performance, indicating that at least 94 publications have each received 94 or more citations.

As illustrated in Figure 2 and Table 2, both the number of publications and citations demonstrate exponential growth, particularly during the 2020–2024 period. This pattern indicates that the research domain focusing on technology adoption and digital startups has emerged as a major area of scholarly attention in recent years. The slight decline projected for 2025 is likely due to the data collection cut-off (September 2025) rather than a genuine decrease in research productivity.

Table 2. Trends in the Estimated Number of Documents and Citations (2015–2025)

Year	Estimated Documents	Estimated Citations
2015	24	95
2016	66	285
2017	113	661
2018	155	1,134

Year	Estimated Documents	Estimated Citations
2019	197	1,606
2020	240	2,268
2021	278	3,024
2022	320	4,347
2023	362	6,058
2024	418	8,991
2025	371	7,758

Taken together, these findings highlight the maturation and intellectual consolidation of the field. The steady increase in publications, the surge in citation counts, and the elevated h-index collectively signify a shift from fragmented exploratory studies toward a theory-building phase that reflects a more established and coherent research agenda within the study of digital transformation and technology adoption in entrepreneurial ecosystems.

4.2. Bibliographic Coupling

Out of a total of 2,243 documents, 64 met the citation threshold of 123, forming four distinct clusters. The selection of this threshold aimed to capture the most impactful and frequently cited studies, ensuring that these 64 documents represent the core body of influential research defining the field. The four clusters correspond to major thematic areas derived from citation linkages and co-authorship patterns.

Among these, the top three documents based on total link strength (TLS) are document [48] with a TLS value of 13, document [49] with a TLS value of 12, and document [50] with a TLS value of 9. The TLS metric indicates the degree of connectivity and influence of each document within the citation network, highlighting its pivotal role in shaping the intellectual structure and central discourse of the field.

Table 3. Top 10 Documents in Bibliographic Coupling Analysis

Rank	Publications	Citation	Total Link Strength
1	McDonald & Eisenhardt [49]	293	13
2	Ghezzi [48]	164	12
3	McDonald & Gao [51]	153	9
4	Gomes et al. [50]	543	9
5	Buccieri et al. [52]	194	8
6	Van Rijnsoever [53]	154	8
7	Autio [54]	149	8
8	Ács [55]	125	8
9	An et al. [56]	149	7
10	Bocken et al. [57]	376	6

Figure 2 presents the network visualization of bibliographic coupling. The four clusters are visibly independent of one another. This discussion examines current trends and future developments in technology adoption among digital startups. The clusters are labeled based on inductive interpretation by revisiting representative articles in the clusters and are synthesized based on common themes and research streams presented.

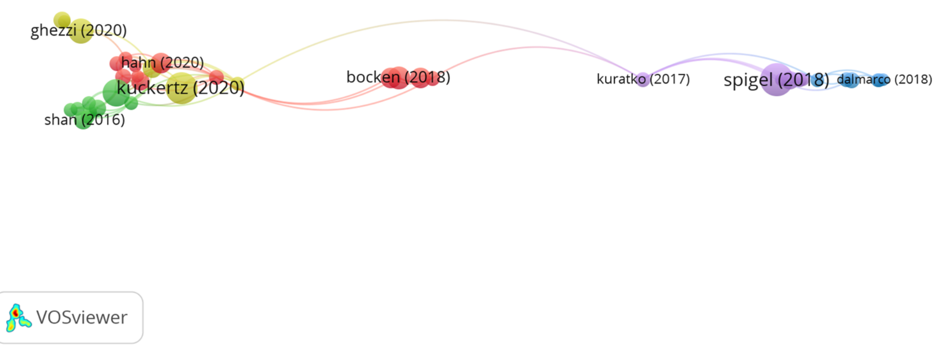

Figure 3. Bibliographic Coupling Technology Adoption in Digital Startups

Table 4. Bibliographic Coupling Analysis on Technology Adoption in Digital Startups

Cluster No and Color	Cluster Label	No. Publications	Typical Publication
1 (red)	Strategic Innovation and Sustainable Business Models	12	[52], [54], [57]–[60]
2 (green)	Transformational Leadership, HR, Innovation, Performance	9	[56], [61]–[64]
3 (blue)	Corporate Entrepreneurship, Innovation, and Collaborative Ecosystems	6	[53], [64]–[66]
4 (yellow)	Strategic Reorientation and Resilience in Entrepreneurship	6	[51], [67]–[70]

4.2.1. Cluster 1 (red): Strategic Innovation and Sustainable Business Models

This cluster highlights the role of strategic innovation in creating sustainable business models, focusing on the integration of environmental and social factors into business strategy to drive long-term value creation. It examines various approaches to sustainable innovation, including the adoption of circular economy models, the role of business model innovation in fostering sustainability, and the strategic reorientation required for businesses to adapt to changing market dynamics [53], [55], [58]. The importance of aligning innovation strategies with sustainability goals is emphasized, as businesses face increasing pressure to deliver value while minimizing environmental impacts and contributing to social good [59], [60]. This cluster also emphasizes the need for dynamic capabilities and open innovation to build resilient and sustainable business models in the face of global challenges [61].

4.2.2. Cluster 2 (green): Transformational Leadership, HR, Innovation, Performance

This cluster underscores the importance of transformational leadership in fostering an environment conducive to innovation, where leaders inspire and motivate employees to embrace change, take risks, and contribute to the organization's strategic goals. Effective HR practices, such as talent management, employee development, and fostering a culture of collaboration, are key drivers of innovation and overall performance [57], [62], [63]. The integration of leadership and HR strategies is particularly crucial for organizations seeking to improve innovation outcomes, as it facilitates the alignment of individual and organizational goals, leading to increased creativity, productivity, and competitive advantage [64], [65]. This cluster also examines the relationship between leadership styles and organizational performance, emphasizing how transformational leadership can enhance the adaptive capacity of organizations in a rapidly changing business environment.

4.2.3. Cluster 3 (blue): Corporate Entrepreneurship, Innovation, and Collaborative Ecosystems

This cluster highlights how organizations can foster a culture of entrepreneurship, driving innovation through internal ventures, intrapreneurship, and strategic partnerships. It emphasizes the role of collaborative ecosystems, where businesses, academic institutions, and external partners work together to accelerate innovation and create value. Corporate entrepreneurship enables organizations to leverage their resources and capabilities to develop new products, services, and business models while maintaining agility in a competitive market [54], [65]. Furthermore, the cluster explores how these collaborative networks, through open innovation and knowledge-sharing practices, enhance the capacity of firms to adapt to market changes and foster sustainable growth [66], [67]. The cluster also examines the challenges and opportunities businesses face in integrating entrepreneurial thinking within established corporate structures and the broader innovation ecosystem.

4.2.4. Cluster 4 (yellow): Strategic Reorientation and Resilience in Entrepreneurship

This cluster examines how entrepreneurial ventures, particularly in times of crisis or rapid market change, must pivot or reframe their strategic directions to maintain competitiveness and achieve long-term sustainability [33], [50]. The importance of strategic reorientation is highlighted, as businesses must be agile and responsive to evolving external environments, including economic disruptions, technological advancements, and shifting customer preferences. Moreover, resilience, both at the organizational and individual levels, is emphasized as a key factor for overcoming setbacks and fostering growth during turbulent times [69], [70]. By leveraging dynamic capabilities, companies can adapt their strategies effectively, ensuring they remain competitive and capable of seizing new opportunities even in uncertain conditions.

4.3. Co-word Analysis

Applying the same database, the co-word analysis identified 13,836 keywords, of which 46 met the specified thresholds, resulting in the formation of three distinct clusters. This analysis allowed for the grouping of related terms based on their co-occurrence patterns, providing valuable insights into the dominant themes and research trends within the dataset. The clusters formed through this process highlight the key areas of focus in the literature, offering a clearer understanding of how different concepts and keywords are interconnected in the field of study.

In this study, the bibliometric analysis of technology adoption in digital startups reveals key thematic clusters that offer valuable insights into the current state of research in this field. A total of 64 documents, meeting the citation threshold of 123, were identified, forming four distinct clusters. These clusters were assigned labels based on their core thematic elements: "Strategic Innovation and Sustainable Business Models," "Transformational Leadership, HR, Innovation, and Performance," "Corporate Entrepreneurship, Innovation, and Collaborative Ecosystems," and "Strategic Reorientation and Resilience in Entrepreneurship." Each cluster represents a critical area of focus within the broader theme of digital startups and technology adoption.

The cluster on "Strategic Innovation and Sustainable Business Models" emphasizes the integration of sustainability into business models, demonstrating the growing importance of environmental and social considerations in innovation strategies. The "Transformational Leadership, HR, Innovation, and Performance" cluster emphasizes how leadership practices, particularly transformational leadership, promote innovation and enhance organizational performance. Meanwhile, the "Corporate Entrepreneurship, Innovation, and Collaborative Ecosystems" cluster highlights the role of internal ventures and strategic partnerships in driving innovation within corporate structures, which is further enhanced by collaborative ecosystems. Finally, the "Strategic Reorientation and Resilience in Entrepreneurship" cluster examines how startups must adapt to external challenges, highlighting the importance of resilience and strategic flexibility in achieving long-term sustainability.

Inter-cluster relationships reveal that these clusters are interconnected, with foundational research areas, such as innovation and entrepreneurship, forming the basis for more specialized research on leadership, resilience, and collaboration. For example, strategic innovation (Cluster 1) is linked to leadership practices (Cluster 2), which in turn support the development of corporate entrepreneurship (Cluster 3). The resilience and strategic reorientation discussed in Cluster 4 are often outcomes of the successful application of innovation and leadership strategies from other clusters.

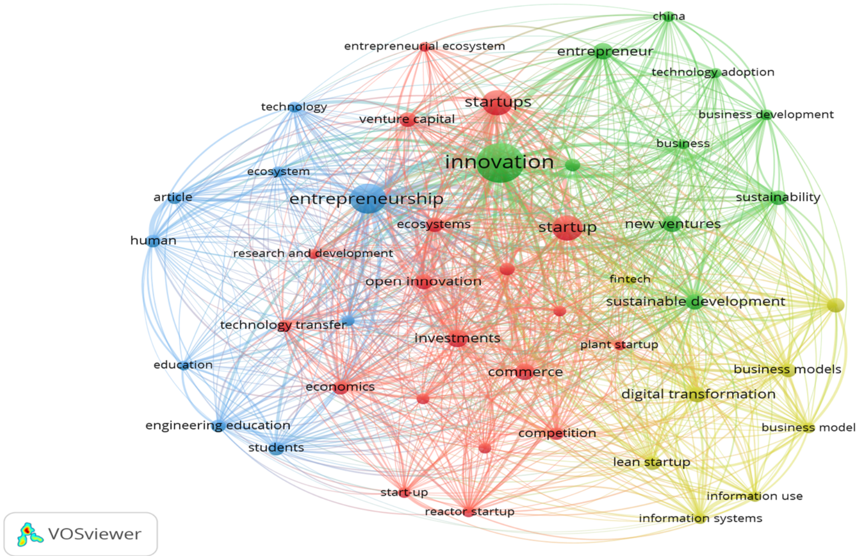

Figure 4. Co-word analysis on Technology Adoption in Digital Startups

Table 5. Bibliographic Coupling Analysis on Technology Adoption in Digital Startups

Cluster No and Color	Cluster Label	No. Publications	Representative Keywords
1 (red)	Innovation and Entrepreneurship Ecosystems	19	Commerce, Competition, Decision Making, Economics, Ecosystems, Entrepreneurial Ecosystems, Innovation Management, Investments, Knowledge Management, Open Innovation, Plant Startup, Reactor Startup, Research and Development, Startups, Technological Innovation, Technology Transfer.
2 (green)	Business Innovation and Sustainability	10	Artificial Intelligence, Business Development, Entrepreneur, Innovation, New Ventures, Sustainability, Sustainable Development, Technology Adoption.
3 (blue)	Educational Ecosystems and Innovation	9	Ecosystem, Education, Engineering Education, Entrepreneurship, Human, Product Development, Students, Technology.
4 (yellow)	Digital Innovation and Business Models	8	Business Model Innovation, Digital Transformation, Fintech, Information Systems, Information Use, Lean Startup.

4.3.1. Cluster 1 (red): labeled Innovation and Entrepreneurship Ecosystems, consists of 19 keywords that highlight the interconnectedness of entrepreneurship, innovation, and ecosystem dynamics.

This cluster emphasizes key aspects of the entrepreneurial process, including commerce, competition, and decision making, which are essential for understanding how businesses operate and thrive in competitive markets [71]. The entrepreneurial ecosystems and innovation management keywords emphasize the importance of supportive environments and management practices for fostering innovation and the growth of new ventures [72]. Key terms such as investments, research and development, and technology transfer reflect the financial and technological resources critical for driving innovation and supporting startups [73]. Additionally, the terms plant startup and reactor startup suggest a focus on the operational challenges and opportunities in new business ventures, especially in industrial and technological contexts [74]–[76]. This cluster encapsulates the broad scope of innovation and entrepreneurship within ecosystems that enable the development, scaling, and sustainability of new ventures.

4.3.2. Cluster 2 (green): labeled Business Innovation and Sustainability, comprises 10 keywords that capture the intersection of innovation, entrepreneurship, and sustainability within business practices.

This cluster focuses on the role of artificial intelligence and technology adoption in driving business innovation, highlighting how advanced technologies are reshaping industries and creating new growth opportunities [77]–[79]. Keywords such as business development, entrepreneur, and new ventures reflect the entrepreneurial journey and the creation of innovative business models that are key to fostering sustainable development [80], [81]. The terms sustainability and sustainable development emphasize the increasing importance of integrating environmental and social considerations into business strategies, ensuring long-term value creation while minimizing negative impacts [82]–[84]. Overall, this cluster underscores the pivotal role of innovation in fostering business practices that are not only economically viable but also socially and environmentally responsible.

4.3.3. Cluster 3 (blue): labeled Educational Ecosystems and Innovation, consists of 9 keywords that emphasize the role of education and innovation within entrepreneurial ecosystems.

This cluster highlights the importance of ecosystems in fostering collaboration between educational institutions, industries, and entrepreneurs to drive innovation [85]–[87]. Education and engineering education are central to the development of skilled individuals who are equipped to contribute to technological advancements and entrepreneurial ventures [88]–[90]. The inclusion of terms such as entrepreneurship, product development, and technology illustrates the critical relationship between educational programs and the ability to innovate and create new products [91]–[93]. Keywords like students and human reflect the human capital aspect, emphasizing the role of individuals in driving innovation through knowledge, skills, and entrepreneurial mindsets [94]–[96]. This cluster underscores the significance of educational ecosystems in nurturing talent and promoting innovation across various sectors.

*4.3.4. Cluster 4 (yellow): labeled Digital Innovation and Business Models***,** *includes 8 keywords that focus on the transformation of business models through digital innovation.*

This cluster emphasizes business model innovation and digital transformation, highlighting how businesses are reimagining their value creation and delivery processes through digital technologies [14], [97], [98]. Keywords like fintech and information systems illustrate the impact of digital technologies on financial services and organizational operations, driving efficiency and new business opportunities [99]–[101]. The term information use points to the critical role of data in shaping business decisions and strategies in the digital age [24], [102]. Additionally, lean startup reflects a methodology that encourages iterative development, rapid prototyping, and pivoting in new business ventures, particularly in the context of digital innovations [103]–[105]. This cluster underscores the pivotal role of digital technologies in reshaping business models, enabling companies to adapt to changing market demands and drive innovation.

The findings of this study provide valuable insights into the evolving landscape of technology adoption in digital startups and highlight directions for future research that can extend existing theoretical frameworks, such as the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT) [25]–[27]. The practical implications underscore the importance of startups integrating sustainability into their business models, adopting transformational leadership practices, fostering innovation through corporate entrepreneurship, and maintaining resilience in the face of external challenges.

Recognizing the limitations of this study such as potential biases arising from keyword selection and database scope future research should examine the influence of external factors, including government policies and market conditions, on technology adoption outcomes. Expanding the temporal scope to trace the evolution of these themes over time and across diverse regions and sectors would also enhance understanding of digital entrepreneurship dynamics.

To interpret the clusters through TAM and UTAUT, we mapped the intellectual structure of the clustering results onto key technology adoption constructs. Cluster 1 (Strategic Innovation and Sustainable Business Models) and the strategy–ecosystem clusters correspond primarily with the TAM construct of Perceived Usefulness, as both demonstrate how technology enhances the value proposition and performance of business models. In contrast, Cluster 2 (Transformational Leadership, HR, Innovation, and Performance) aligns more closely with UTAUT dimensions, particularly Facilitating Conditions and Social Influence, which emphasize the importance of leadership, organizational support, and HR practices in strengthening readiness, legitimacy, and the diffusion of technology adoption at the organizational level.

4.4. Implications

These findings indicate a conceptual shift from individual-level constructs in TAM toward macro-level strategic and exosystemic determinants. The emergence of themes such as transformational leadership, intrapreneurship, and cross-actor collaboration suggests that technology adoption in digital startups extends beyond internal firm decisions to encompass processes mediated by resource orchestration, knowledge networks, and dynamic capabilities. Accordingly, this study proposes a conceptual integration of TAM/UTAUT with the dynamic capabilities and innovation ecosystem frameworks to capture the sensing–seizing–reconfiguring mechanisms that link technological adoption with organizational performance and resilience.

For startup founders, the primary managerial priority is to align technology investments with sustainable business model innovation while cultivating leadership and HR practices that encourage managed experimentation and rapid learning. Expanding ecosystem partnerships among industry, universities, and government entities can further accelerate knowledge flows and co-specialization of assets.

For policymakers, the findings underscore the importance of implementing supportive policy instruments, including targeted incentives, clear and consistent regulatory frameworks, and robust data infrastructure, to enhance facilitative conditions and reduce coordination costs among stakeholders.

4.5. Limitations and Future Research

This study explicitly acknowledges both methodological limitations (e.g., reliance on a single database, keyword selection, and co-occurrence thresholds) and conceptual limitations (e.g., thematic scope that may omit certain institutional variables). Future research should focus on examining the mediating role of policy, regulation, and institutional frameworks in technology adoption; exploring temporal dynamics across periods and regions; and integrating non-financial performance indicators to evaluate the contribution of technology to sustainability.

Advancing along this trajectory will enrich the synthesis of technology adoption Theory within digital startup ecosystems and support the formulation of more precise policy interventions and organizational strategies.

5. CONCLUSIONS

This study provides valuable insights into technology adoption in digital startups by mapping the intellectual structure and dominant research themes through bibliometric analysis. The findings indicate a shift from narrowly focused adoption models toward a broader, integrative framework grounded in strategy and ecosystem perspectives. Four primary thematic clusters were identified as central to the field: sustainable business models, corporate entrepreneurship, innovation ecosystems, and digital business transformation. These results highlight the crucial role of cross-industry collaboration and the impact of policy and regulatory frameworks in driving technology adoption among digital startups, thereby fostering sustainability and business scalability.

Building on this mapping, the study proposes a future research agenda that emphasizes multi-level models connecting cognition, organizational capabilities, and startup growth. Moreover, quasi-experimental evaluations should be conducted to examine interface simplification and user onboarding processes, alongside cross-country comparative analyses to assess how regulatory differences affect technology adoption. Collectively, the findings of this study deepen the understanding of technological dynamics in digital entrepreneurship and make a substantive contribution to advancing both Theory and practice in sustainable digital economies.

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