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RISK AND INNOVATION IN TECHNOLOGY STARTUPS: MAPPING THE INTELLECTUAL STRUCTURE AND FUTURE RESEARCH DIRECTIONS

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ABSTRACT

This study maps the development, intellectual structure, and emerging research directions of literature on risk and innovation in technology startups. Using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, 54 Q1 Scopus-indexed articles published between 2022 and 2026 were selected from 77 initial records. Bibliometric analysis was conducted using publication and citation analysis, keyword co-occurrence, reference co-citation, and country co-authorship, with VOSviewer and SCImago Graphica used for network and geographical visualization. The findings show that publication activity increased after 2023, while the literature remains dispersed across journals and concentrated in several countries, particularly China, the United States, the United Kingdom, and Spain. Keyword analysis identifies a conceptual structure connecting innovation, venture capital, investment, technology adoption, digital innovation, artificial intelligence, sustainability, and technological development. Co-citation analysis shows that the field draws on resource-based, dynamic capability, entrepreneurship, and venture capital perspectives. International collaboration is present but remains divided across several country clusters. These findings indicate that research on risk and innovation in technology startups has developed through multiple connected but only partially integrated streams. This study contributes by organizing the field's conceptual, intellectual, and collaboration structures and by identifying future research opportunities related to conceptual integration, emerging technology risk, financing, startup ecosystems, and methodological development.

Keywords: *Bibliometric Analysis, Innovation, Risk, Technology Startups*

A. INTRODUCTION

Technology startups commercialize new technologies and develop business models around products and services whose markets may still be forming. They operate in environments shaped by artificial intelligence (AI), digital platforms, and other emerging technologies that influence how new ventures develop products, obtain capital, and compete. In 2024, venture capital funding for AI and big data startups increased by 33%, and these startups received 40% of global venture capital investment (Startup Genome, 2025). This concentration reflects the strong allocation of venture capital toward AI-related opportunities. At the same time, technology startups must make development and investment decisions before demand, technological feasibility, and regulatory conditions are fully known. Risk and innovation are therefore closely connected to how these ventures develop and commercialize new technologies.

Risk is inherent in entrepreneurial activity because many decisions are made before their outcomes can be estimated with confidence. Knight's distinction between measurable risk and uncertainty remains relevant to entrepreneurship because novel knowledge and market opportunities often lack established probability distributions (Audretsch & Belitski, 2021). Audretsch and Belitski (2021) show that uncertainty surrounding knowledge, commercialization, and market demand affects whether new knowledge is converted into entrepreneurial activity. Technology ventures also face risks arising from technological novelty and uncertain customer requirements. Sadeh and Dvir (2020) find that higher technological risk can require longer development periods and additional design cycles, while market uncertainty affects how customer information is incorporated into product development. Other studies identify financial, regulatory, and organizational sources of risk in technology-oriented ventures (Maréchal et al., 2025; Patra et al., 2025). Risk in technology startups therefore extends across several dimensions that affect venture development and commercialization.

Innovation is also central to technology startups because these ventures frequently compete through new products, technologies, services, and business models. Digital startups may change their value architecture and business models during early development as they search for viable ways to create and capture value (Ghezzi & Cavallo, 2020). Innovation can support differentiation and market creation, but it also requires startups to allocate scarce resources before commercial outcomes are established. Evidence from 331 information and communication technology ventures shows that higher innovativeness is associated with greater uncertainty and trade-offs between innovativeness, speed to break-even, and revenue at break-even (Estrin et al., 2025). These trade-offs suggest that innovation should be examined as both a source of entrepreneurial opportunity and a process that changes the uncertainty surrounding venture development.

The relationship between risk and innovation becomes particularly relevant when technology startups move from experimentation to commercialization. Greater technological novelty may create new market opportunities while increasing development requirements, information gaps, and exposure to uncertain customer responses. Sadeh and Dvir (2020) show that technological risk and market uncertainty do not necessarily prevent venture success, although they affect how development and market strategies should be organized. Evidence from construction technology startups similarly identifies business model innovation, organizational capabilities, ecosystem support, uncertainty, and market-related risks as factors associated with startup development (Yucel & Azhar, 2024). Evidence from ICT ventures further shows that resource constraints shape the trade-offs between innovativeness and early commercial outcomes (Estrin et al., 2025). Risk and innovation are thus connected through technology development, resource allocation, market validation, and commercialization decisions.

Despite these connections, the literature remains distributed across several research streams. Entrepreneurial finance examines venture capital, valuation, investor strategy, information asymmetry, and financing instruments (Dekker et al., 2026; Maréchal et al., 2025; Wang et al., 2023) Behavioral research focuses on founder risk propensity, entrepreneurial decision-making, and differences between founders and investors (Elitzur et al., 2025; Hagenauer & Zipko, 2024; Walzer et al., 2025). Technology and innovation studies examine digital capabilities, resource orchestration, adoption barriers, and experimentation (Fan et al., 2026; Fodouop Kouam, 2026; Shi et al., 2026). Other studies address responsible innovation, digital governance, regulation, geopolitical uncertainty, ecosystem support, and platform dependence (Alshibani et al., 2025; Chen et al., 2026; Rothstein, 2025; Salgado-Criado et al., 2024). These streams differ in their theoretical foundations, units of analysis, operational definitions, and research methods. As a result, findings relevant to the risk–innovation relationship are dispersed across entrepreneurship, finance, innovation management, technology management, governance, and related fields.

Previous reviews and review-based studies tend to examine narrower parts of this domain. Yucel and Azhar (2024) review critical success factors and risks in construction technology startups, while Patra et al. (2025) concentrate on barriers to blockchain adoption in international entrepreneurship. Yamini et al. (2025) examine risk and investment strategies in renewable-energy technologies, where commercialization requires substantial capital and long development periods. These studies clarify specific sectors or mechanisms, but they do not jointly map how the broader literature on risk, innovation, and technology startups is organized. Three gaps follow from this fragmentation. First, the conceptual structure remains unclear because risk and innovation represent different mechanisms and outcomes across the literature. Second, the intellectual foundations and international collaboration patterns remain insufficiently synthesized across these research streams. Third, the literature provides limited integrated evidence on how the field has developed and which unresolved relationships can inform subsequent research. Addressing these gaps requires systematic mapping of both the development and knowledge structure of the field.

This study addresses these gaps by combining the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework with bibliometric analysis of Scopus-indexed research. The analysis examines publication development, disciplinary and geographical distribution, conceptual

themes, intellectual foundations, and international collaboration in research on risk, innovation, and technology startups.

Three research questions guide the study.

RQ1: What are the trends in yearly publications and citations, Scopus subject areas, leading journals, and geographical distribution in research on risk, innovation, and technology startups?

RQ2: What are the conceptual themes, intellectual foundations, and international collaboration patterns in the field?

RQ3: What are the emerging research directions in risk and innovation research related to technology startups?

The remainder of the article is organized as follows. Section B explains the research methods, data source, search strategy, and article-selection process. Section C presents the descriptive and bibliometric results for RQ1 and RQ2, discusses the findings in relation to the existing literature, and develops future research directions in response to RQ3. Section D concludes the study and presents its contributions and limitations.

B. METHOD

This study combines PRISMA and bibliometric analysis. PRISMA provides a transparent process for identifying, screening, and selecting relevant articles (Page et al., 2021), while bibliometric analysis examines research development and relationships among publications, keywords, references, and countries (Donthu et al., 2021). Publication and citation trends, Scopus subject areas, leading journals, and geographical distribution were analyzed for RQ1. Keyword co-occurrence, reference co-citation, and country co-authorship analyses were conducted for RQ2 using VOSviewer (van Eck & Waltman, 2010), while SCImago Graphica was used to visualize geographical distribution. Finally, the bibliometric findings were integrated to identify research gaps and develop emerging research directions for RQ3.

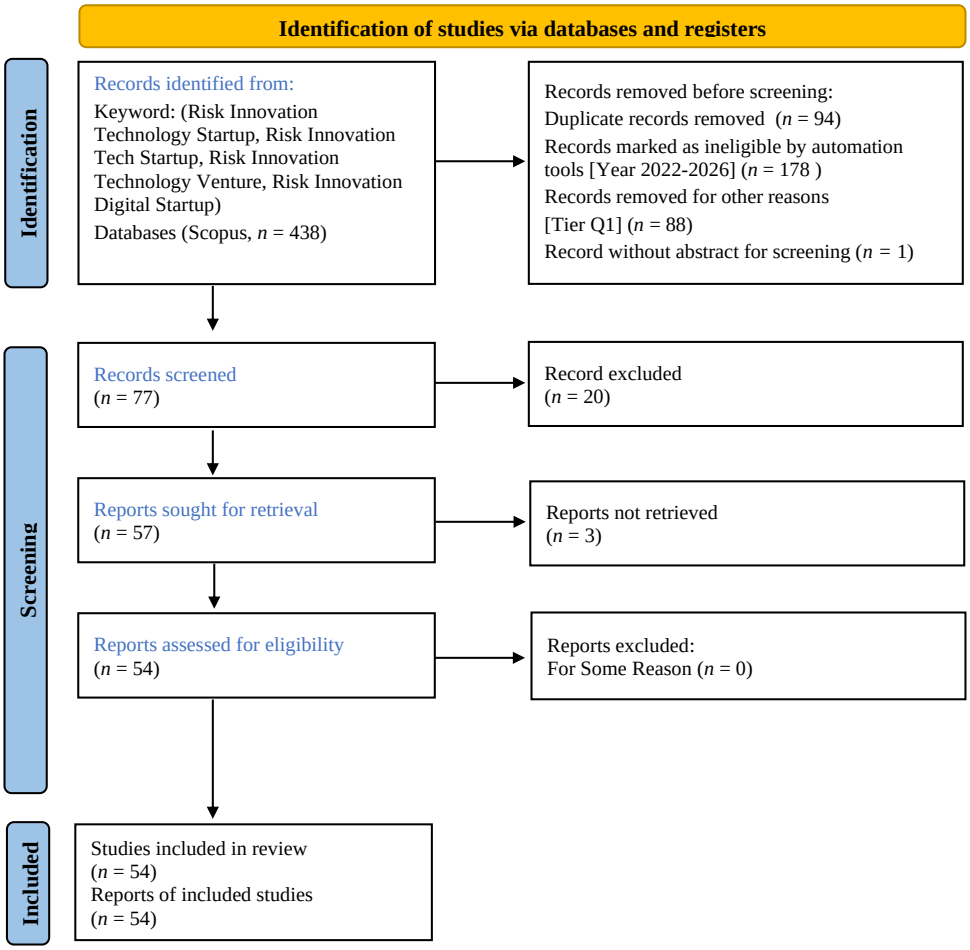
The literature search was conducted in the Scopus database using four keyword combinations: "*Risk Innovation Technology Startup*" *OR* "*Risk Innovation Tech Startup*" *OR* "*Risk Innovation Technology Venture*" *OR* "*Risk Innovation Digital Startup.*" The search covered titles, abstracts, and keywords and was limited to publications from 2022 to 2026 in Quartile 1 (Q1) journals and the data were extracted on August 5, 2026. The inclusion and exclusion criteria are presented in Table 1. The search identified 77 records, of which 20 were excluded during title and abstract screening, comprising 13 review-based studies, two non-eligible documents (one note and one erratum). Three additional reports could not be retrieved in full text, resulting in 54 articles included in the final bibliometric analysis. The article-selection process is presented in Figure 1.

Table 1. Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion
Publication period	2022-2026	Outside this range
Document type	Research article (Scopus document type: Article)	Book chapter, conference paper, review
Language	English	Other languages
Journal quartile	Quartile 1 (Q1) according to the SCImago Journal Rank	Q2, Q3, Q4 and unindexed journals
Accessibility	Full-text available	Full-text inaccessible
Relevance	Risk and innovation in technology startup context	Outside the research scope

Source: Authors' elaboration

Figure 1. PRISMA Flow Diagram of the Article Selection Process

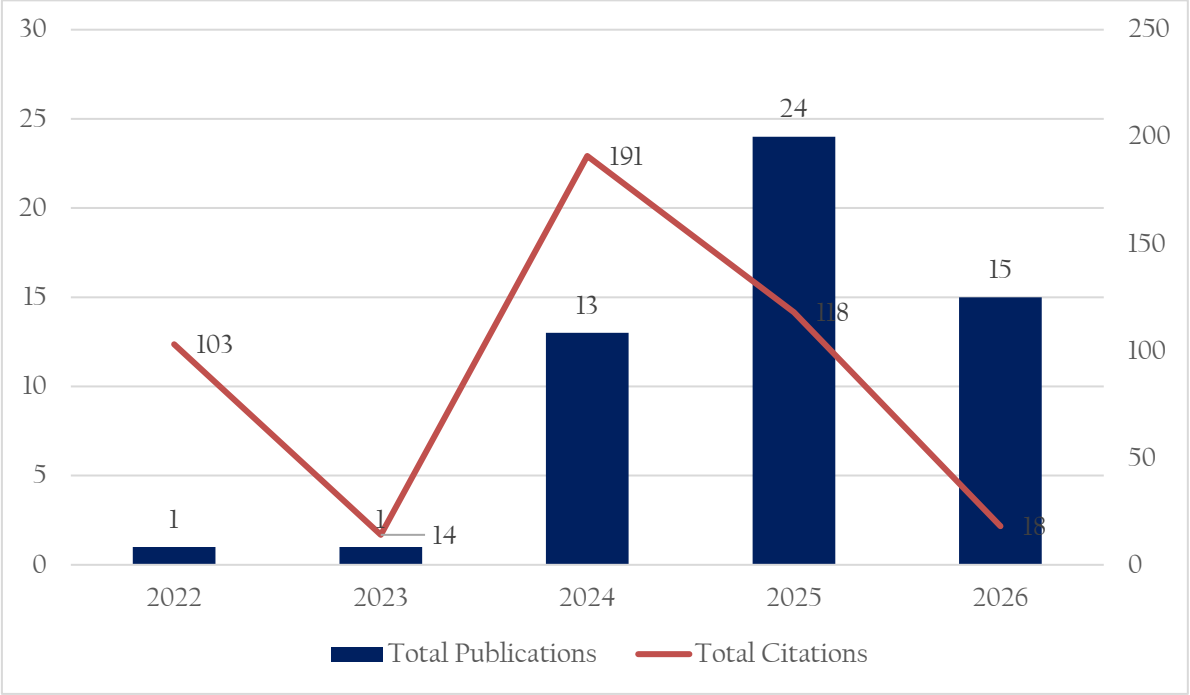


Source: Authors' elaboration

C. RESULTS AND DISCUSSION

Descriptive Analysis (RQ1)

Figure 2 depicts the publication and citation trends in research on risk and innovation in technology startups from 2022 to 2026. Publication activity remained limited during the first two years and increased substantially from 2024, reaching its highest level in 2025. Citation activity followed a different pattern, with articles published in 2024 receiving the highest citation count. The lower citation count for 2026 should be interpreted cautiously because the year is still incomplete and recent articles have had less time to accumulate citations. Overall, the pattern indicates that the field has expanded in recent years, while its citation impact is currently concentrated in earlier publications.



Source: Scopus data processed by the authors.

Figure 2. Publication and Citation Trends by Year, 2022 to 2026

Table 2 presents the ten leading Scopus subject areas represented in the selected articles. Business, Management and Accounting is the dominant field, while Economics, Econometrics and Finance, Social Sciences, Decision Sciences, Computer Science, and Engineering also make substantial contributions. The presence of both management-oriented and technology-oriented subject areas reflects the intersection of entrepreneurial, financial, and technological perspectives within the literature. This disciplinary distribution indicates that research on risk and innovation in technology startups has developed as a multidisciplinary field rather than within a single academic discipline.

Table 2. Top 10 Scopus Subject Areas

Subject Area	Articles
Business, Management and Accounting	29
Economics, Econometrics and Finance	13
Social Sciences	12
Decision Sciences	10
Computer Science	9
Engineering	8
Energy	4
Multidisciplinary	4
Arts and Humanities	3
Environmental Science	3

Source: Authors' elaboration based on Scopus data.

Table 3 summarizes the leading journals in the dataset. The 54 articles were distributed across 45 journals, with only a small number of outlets publishing more than one article. PLoS ONE recorded the highest publication output, while several journals in entrepreneurship, innovation, finance, sustainability, and technology management contributed two articles each. The wide dispersion across publication outlets is consistent with the multidisciplinary subject-area distribution reported in Table 2. This pattern suggests that the field has not yet developed a strongly concentrated group of specialist journals.

Table 3. Leading Journals

Journal	Publications
PLoS ONE	3
AI and Society	2
FinTech	2
International Entrepreneurship and Management Journal	2
Research Policy	2
Small Business Economics	2
Sustainability	2
Technological Forecasting and Social Change	2

Source: Authors' elaboration based on Scopus data.

Figure 3 illustrates the geographical distribution of the selected articles. Researchers from 35 countries contributed to the literature, indicating that the topic has attracted attention across several regions. China represents the largest contributor, followed by the United States, the United Kingdom, and Spain, while contributions from many other countries remain limited. The map also shows participation from Europe, Asia, North America, South America, the Middle East, and Oceania. Despite this international coverage, the distribution indicates that research activity remains concentrated in a relatively small number of countries.

Source: Scopus data processed using SCImago Graphica.

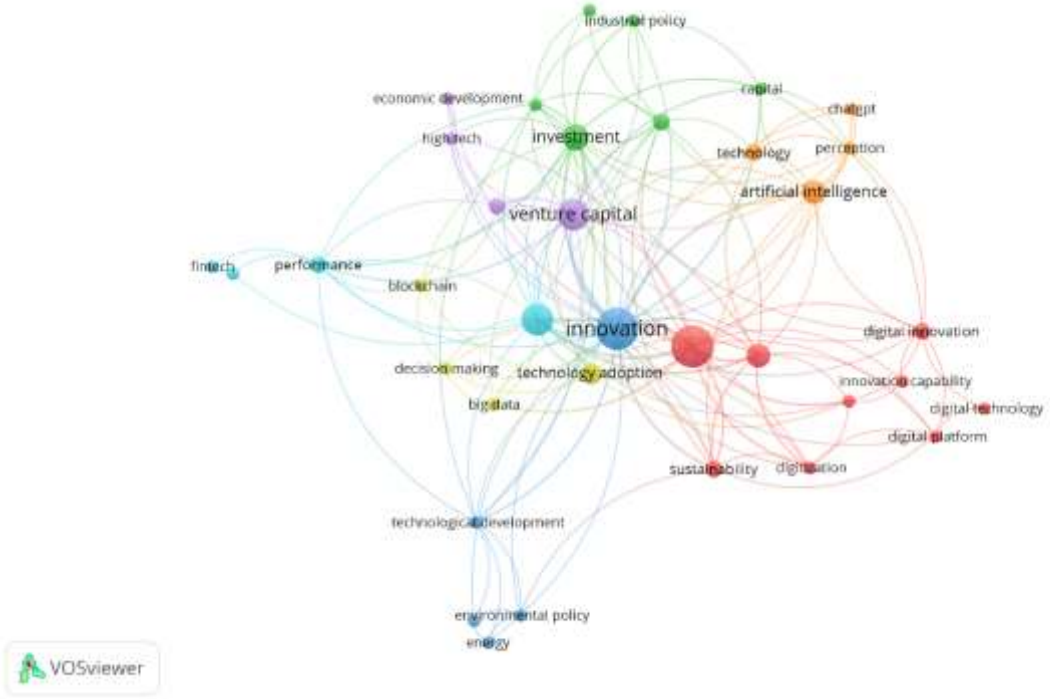
Figure 3. Geographical Distribution of Publications

The findings in this subsection show that research on risk and innovation in technology startups has expanded in recent years, while publication activity remains dispersed across journals and concentrated in several countries. The field also draws on multiple disciplines, particularly business, finance, social science, computing, and engineering. These patterns summarize the publication characteristics and development of the literature addressed in RQ1.

2. Bibliometric Analysis (RQ2)

Figure 4 presents the keyword co-occurrence network based on a minimum threshold of two occurrences. The analysis identified 36 keywords grouped into seven clusters. Rather than being organized around a single topic, the conceptual structure connects several related themes, including digital innovation, venture capital and investment, technology adoption, artificial intelligence, fintech, sustainability, and technological development. Innovation occupies a central position in the network and

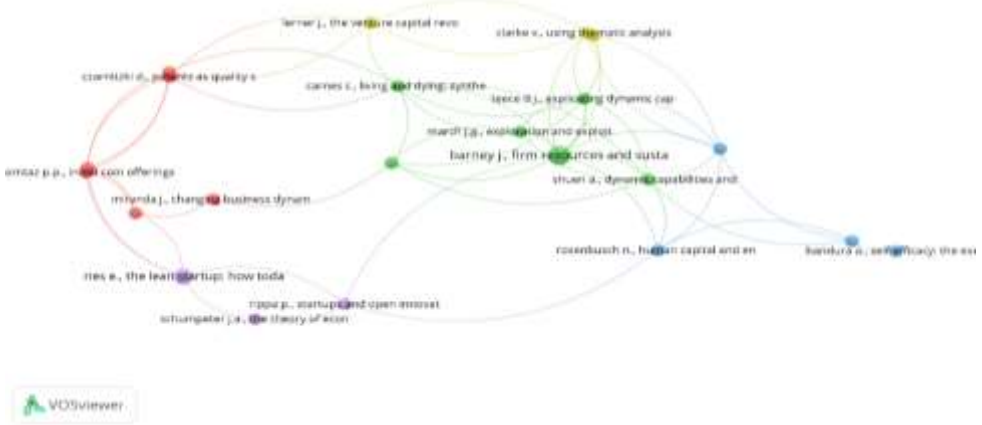
links several of these themes, while venture capital and investment form another visible area of concentration. The network therefore indicates that the literature connects technological development with financing, adoption, and risk-related issues, although these themes remain distributed across several clusters.



Source: Scopus data processed using VOSviewer.

Figure 4. Keyword Co-occurrence Network Visualization

Figure 5 shows the reference co-citation network using a minimum threshold of two citations. The analysis identified 22 frequently co-cited references grouped into five clusters. The most visible intellectual foundations are associated with the resource-based view and dynamic capabilities, represented by works such as Barney and Teece, together with literature on exploration and exploitation, venture capital, entrepreneurship, and startup development. Other clusters connect these foundations with self-efficacy, human capital, innovation finance, and lean startup perspectives. The network suggests that the field draws on several established theoretical traditions rather than a single dominant intellectual foundation, with capability-based and innovation-oriented perspectives occupying a central position.

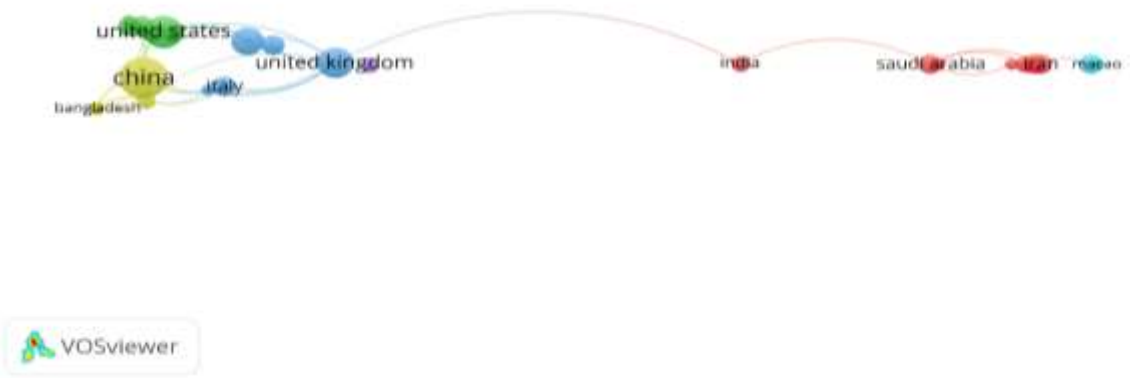


Source: Scopus data processed using VOSviewer.

Figure 5. Co-citation Network Visualization

Figure 6 presents the country co-authorship network using a minimum threshold of one document per country. The analysis included 27 countries and identified six collaboration clusters. China, the United States, and the United Kingdom appear among the more visible contributors in the network, while other

countries are connected through smaller regional or cross-country groups. The network also shows that collaboration is uneven, with several countries positioned in relatively separate clusters rather than forming one highly integrated international network. This pattern indicates that research collaboration has an international reach, but stronger connections across existing country clusters remain limited.



Source: Scopus data processed using VOSviewer.

Figure 6. Country Co-authorship Network Visualization

The findings in this subsection show that the literature is structured around interconnected themes of innovation, technology, financing, and risk, while its intellectual foundations draw from several theoretical traditions. International collaboration is also present but remains divided across several country clusters. These patterns explain the conceptual, intellectual, and collaboration structures of the literature addressed in RQ2.

3. Discussion

The descriptive findings indicate that research on risk and innovation in technology startups has expanded in recent years but remains dispersed across journals and unevenly distributed across countries. The multidisciplinary subject areas suggest that the field has developed at the intersection of entrepreneurship, finance, innovation management, and technology studies. This pattern is consistent with previous research that approaches startup risk from different perspectives, including venture financing, technological uncertainty, digital governance, and organizational capabilities (Maréchal et al., 2025; Salgado-Criado et al., 2024; Shi et al., 2026). The geographical concentration also reflects the strong use of country-specific settings in previous studies, particularly China, the United States, and European economies. Although these contexts provide important empirical evidence, broader comparative research is still needed to determine whether the identified relationships apply across different startup ecosystems.

The keyword structure provides a clearer view of how risk and innovation are connected within the field. Innovation occupies a central position and connects themes related to venture capital, investment, technology adoption, digital innovation, artificial intelligence, sustainability, and technological development. Risk, however, does not appear as a single isolated research stream. Instead, it is embedded within financing, technological adoption, performance, and entrepreneurial decision-making. This pattern is consistent with empirical studies showing that innovation may create both opportunities and additional uncertainty. Big data adoption can improve performance among surviving startups while increasing exposure to failure (Rodepeter et al., 2026), while excessive data allocation can create resource redundancy and technological path dependence (Shi et al., 2026). Responsible AI research also shows that innovation increasingly requires attention to ethical and governance risks alongside entrepreneurial risk-taking (Alshibani et al., 2025). These findings suggest that the relationship between risk and innovation is better understood as conditional rather than uniformly positive or negative.

The co-citation structure further indicates that the field draws from several intellectual traditions. Resource-based and dynamic capability perspectives occupy a central position, alongside research on exploration, exploitation, venture capital, entrepreneurship, human capital, self-efficacy, and lean startup

development. This structure reflects the importance of organizational capabilities in explaining how startups respond to uncertainty and convert technological resources into innovation outcomes. Similar mechanisms appear in studies showing that digital technologies create value only when firms can integrate, coordinate, and reconfigure their resources effectively (Fan et al., 2026; Fodouop Kouam, 2026; Shi et al., 2026). At the same time, the presence of venture capital and investment literature shows that internal capabilities alone do not explain startup innovation because access to capital, investor knowledge, and financing conditions also shape the ability to pursue uncertain projects (Li et al., 2025; Wang et al., 2023). The intellectual structure therefore combines capability-based and financing perspectives, but these foundations remain only partially integrated.

International collaboration provides another indication of fragmentation within the field. Although researchers from multiple countries contribute to the literature, the co-authorship network remains divided into several collaboration clusters. This pattern parallels the strong dependence of empirical research on specific national and institutional settings. Studies of technology startups have examined contexts such as China, Israel, Brazil, Germany, and other individual ecosystems, where financing systems, regulation, technological infrastructure, and investor behavior may differ substantially. These contextual differences are important because startup risk is influenced not only by firm characteristics but also by institutional support, capital availability, and the surrounding innovation ecosystem. Limited links between collaboration clusters may therefore reduce opportunities to compare how risk and innovation operate across different institutional environments. Stronger cross-country collaboration could help distinguish context-specific findings from relationships that are more widely applicable.

Taken together, the findings show that research on risk and innovation in technology startups has developed into a multidisciplinary knowledge base, but integration across its main themes remains limited. Risk appears across financial, technological, behavioral, governance, and ecosystem perspectives, while innovation is examined through technology adoption, digital capabilities, financing, and entrepreneurial experimentation. The field therefore contains several related explanations rather than one dominant framework for understanding how startups manage uncertainty while pursuing innovation. This fragmentation provides the basis for identifying research directions that connect previously separate themes, broaden empirical contexts, and examine the conditions under which innovation creates value or increases exposure to risk. These unresolved issues are developed further in the future research directions subsection.

4. Future Research Directions (RQ3)

Based on the bibliometric findings and discussion, several research directions emerge from the current structure of the literature. The main gaps concern the limited integration between risk and innovation perspectives, the strong dependence on specific countries and industries, the growing role of artificial intelligence and digital technologies, and the need to examine risk across different stages of startup development. These gaps suggest that future research should connect financial, technological, behavioral, and ecosystem perspectives more explicitly rather than examining them as separate streams.

Table 4. Future Research Agenda

Priority Area	Future Research Direction
Conceptual Integration	Future studies should integrate risk and innovation within a common framework by connecting technological capability, entrepreneurial finance, founder behavior, and ecosystem conditions.
Dynamic Risk and Innovation	Future research should examine how the relationship between risk and innovation changes across startup stages and whether this relationship is linear, non-linear, or conditional on organizational capabilities.
AI and Digital Technology Risk	Future studies should investigate how artificial intelligence, digital platforms, big data, and other emerging technologies affect innovation while creating technological, ethical, governance, and decision-related risks.

Priority Area	Future Research Direction
Financing and Investor Alignment	Future research should examine how venture capital, alternative financing, investor characteristics, and founder-investor alignment influence risk-taking, innovation decisions, and startup outcomes.
Geographical and Ecosystem Expansion	Future studies should compare startup ecosystems across countries and regions to examine how regulation, capital availability, institutional support, and technological infrastructure shape the risk and innovation relationship.
Methodological Development	Future research should use longitudinal, cross-country, multi-level, and mixed-method designs to capture changes in risk, capabilities, and innovation throughout the startup lifecycle.

Source: Authors' elaboration based on the bibliometric analysis and literature synthesis.

The first research priority concerns stronger conceptual integration. The keyword and co-citation findings show that innovation, investment, venture capital, technology adoption, and digital technologies are connected, but the literature still draws on several intellectual traditions that are only partially integrated. Previous studies also show that innovation can increase performance while creating additional uncertainty, resource requirements, or coordination costs (Fan et al., 2026; Rodepeter et al., 2026; Shi et al., 2026). Future research could therefore examine the conditions under which technological capabilities, access to finance, organizational resources, and founder characteristics strengthen or weaken the relationship between risk and innovation. A lifecycle perspective would be particularly useful because the sources and consequences of risk may differ between formation, early financing, scaling, and exit stages.

A second research priority arises from the increasing use of artificial intelligence and other digital technologies in startup activities. Existing studies indicate that these technologies can support experimentation, decision-making, and radical innovation, but they can also introduce technological, ethical, governance, and cognitive risks (Alshibani et al., 2025; Fodouop Kouam, 2026; Rady et al., 2026) At the same time, the geographical and collaboration findings show that the current evidence remains concentrated in several countries and research networks. Future studies should therefore examine emerging technologies across different startup ecosystems and institutional settings, while using research designs that capture changes over time. This direction can help determine which risk and innovation mechanisms are specific to particular contexts and which are more widely applicable across technology startups.

D. CONCLUSION

This study mapped the development and knowledge structure of research on risk and innovation in technology startups using 54 Q1 Scopus-indexed articles published between 2022 and 2026. The descriptive analysis shows that publication activity increased after 2023, while the literature remains dispersed across journals and concentrated in several countries. The bibliometric analysis identifies a conceptual structure centered on innovation, venture capital, investment, technology adoption, digital innovation, artificial intelligence, and related themes. The co-citation network shows that the field draws on resource-based, dynamic capability, entrepreneurship, and venture capital perspectives, while the co-authorship analysis indicates that international collaboration remains divided across several country clusters. These findings show that the field has developed through multiple connected research streams, but stronger integration between financial, technological, behavioral, and ecosystem perspectives is still needed.

This study contributes to the literature by providing an integrated map of how risk and innovation are studied within technology startup research. Theoretically, it clarifies the main conceptual and intellectual foundations of the field and shows how innovation is connected with financing, technology adoption, organizational capabilities, and different forms of risk. Methodologically, the study combines PRISMA with descriptive and science-mapping techniques to examine publication development, thematic relationships, intellectual foundations, and international collaboration within a single review design. Practically, the findings provide relevant insights for startup founders, investors, incubators, accelerators,

and policymakers by showing that innovation decisions should be considered together with financing conditions, organizational capabilities, governance, and the broader startup ecosystem.

This study has several limitations. First, the review is limited to Q1 journals indexed in Scopus between 2022 and 2026, which may exclude relevant studies published in other databases, journal quartiles, or earlier periods. Second, the search strategy is based on four keyword combinations, so articles using different terminology for technology startups, risk, or innovation may not have been retrieved. Third, bibliometric results depend on publication metadata, citation patterns, keyword selection, and thesaurus cleaning, which may affect the structure of the resulting networks. Finally, citation-based analysis may favor older articles because recent publications have had less time to accumulate citations. Future reviews could broaden database coverage, extend the publication period, and compare bibliometric patterns across different types of technology startups and innovation ecosystems.

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