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ORIGINAL PAPER

Digital innovation in entrepreneurial firms: a systematic literature review

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Abstract

Entrepreneurial firms are central actors in the process of the generation and diffusion of digital innovation which, on the other hand, provides a wide range of opportunities for entrepreneurs. Although existing research has produced several contributions on both topics, the knowledge generated in the field appears fragmented and the findings are sometimes ambiguous. The reason for this fragmentation can be traced back to the lack of reference frameworks that clarify the most used concepts, thus providing a shared language. This study aims to consolidate the state-of-art of scholarly research published over the past 20 years at the intersection of the innovation and entrepreneurship fields of study. To this aim, we carried out a systematic literature review by analyzing a set of 185 papers in order to find what are the relevant topics in the investigated research domain. This activity was performed using MySLR software. Besides a descriptive picture of the scientific activity, a map of the literature published to date that simultaneously addresses the two themes, is provided. In particular, we characterized the six relevant topics in the investigated research domain: start-ups' collaboration networks, business-model innovation, digital platforms, digital ventures, the digital entrepreneur's profile, and digital-innovation ecosystems. Based on these results the article proposes three main research directions for future research: multi-level analysis of Digital Innovation in Entrepreneurial Ventures; interdisciplinary approaches; development of specific theories for igital Innovation. Overall, the value of research is to provide a framework for analyzing the phenomenon of innovation in and with entrepreneurial firms that can be used as a reference model for both entrepreneurship and innovation management researchers.

Keywords Digital innovation · Entrepreneurship · Digital transformation · Start-ups · Digital technology

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1 Introduction

Companies today operate in an uncertain and dynamic context, within which digital technologies contribute to accelerating the pace of change (Ghezzi and Cavallo 2020) and can boost the generation of value and the exploitation of new business ideas (Spender et al. 2017). By leveraging new digital technologies, companies are transforming their business models (Kohli and Melville 2019). Not only do companies and public administrations adopt the available technologies, but they bend them to their own needs by generating new methods of use or, in many cases, helping to generate new digital tools. This phenomenon can be referred to as digital innovation and can be defined as the process of the adoption (Jeyaraj et al. 2006), generation, or recombination of new digital technologies (Lee and Berente 2012).

As observed by Autio et al. (2014), several disruptive digital innovations have been introduced over the years by entrepreneurial firms (e.g. electronic calculators, personal computers, and Internet search engines). Entrepreneurial firms have been defined as small and medium-sized enterprises (SMEs) that translate ideas and technologies into new products, services, processes, or business models (Brown et al. 2018). While for decades the scientific literature on innovation management has focused on innovations in large companies (e.g. Dougherty and Hardy 1996; Leifer et al. 2000; O'Connor and Rice 2001; Baumol 2004; O'Reilly and Tushman 2004; O'Connor 2008), more recently, a substantial amount of the literature in the field has begun to deal with entrepreneurial firms, both in terms of the fact that they produce digital innovation and that they are influenced by digital innovation in their operations (Alsaathy 2011; Bahl et al. 2021).The relationship between digital innovation and entrepreneurship is twofold. On the one hand, in recent years, digitalization has been opening up fascinating innovation opportunities for entrepreneurial firms (Secundo et al. 2020). In the digital technologies sector, where, often, the innovation processes do not require large investments and capital immobilization (Leliveld and Knorringa 2018), innovation has become accessible even to small entrepreneurial firms (Wymer and Regan 2005). On the other hand, many contributions in the literature suggest that entrepreneurial enterprises play a central role in generating digital innovation (Kraus et al. 2019a, b). Entrepreneurial firms strongly contribute to digital innovation as they play a key role in the exploration of new technological domains and market opportunities (Ferreira et al. 2019).

Digital innovation offers new opportunities for companies to increase the value created for their clients through novel products and services (Yoo et al. 2010; Åström et al. 2022), generating new business models (Richter et al. 2015) and enhancing their long-term success (Nylén and Holmström, 2015; Soluk and Kammerlander 2021). Entrepreneurial firms can use digital search to identify new opportunities for innovation and how this can impact their performance (Ardito and Capolupo 2023). Innovation can help entrepreneurial firms creating shared value, driving sustainable growth and achieving long-term success (Rubio-Andrés et al. 2022). However, entrepreneurs face challenges in identifying potential opportunities and

pursuing them effectively due to limitations in knowledge, resources, and networks. These barriers need to be addressed for entrepreneurship to drive digital innovation in firms (Khanin et al. 2022). The fields of entrepreneurship and digital innovation involve the combination of digital technologies with traditional entrepreneurship and innovation practices and results. Digital entrepreneurship can be considered as a sub-category of entrepreneurship, involving the digitization of some or all aspects of a traditional organization (Hull et al. 2007). The advent of new digital technologies has fundamentally modified the nature of the entrepreneurial process and its resulting outcomes, prompting significant questions at the intersection of digital technologies and entrepreneurship (Nambisan 2017). Scholars suggest that digital technologies break down traditional barriers and change the way entrepreneurship and innovation processes and outcomes occur, making current theories potentially outdated and leading to the need for investigation of these intersections as new phenomena (Berger et al. 2021). Actually, there is a growing divide between entrepreneurial companies that are able to effectively leverage on digital innovation and those that are not, and that this divide is largely driven by the skills and capabilities of the workforce (Shakina et al. 2021).

A considerable amount of literature on digital innovation and entrepreneurial firms exists. Several special issues of international journals have been published to stimulate the debate on the topic and several review papers have analyzed specific aspects of the phenomenon (e.g. Kraus et al. 2019a, b; Nambisan et al. 2019). While reviews of the literature exist on digital entrepreneurship (Kraus et al. 2018; Satalkina and Steiner 2020), digital transformation (Kraus et al. 2021), and digital innovation (Di Vaio et al. 2021), as well as with specific reference to SMEs (Ramdani et al. 2021), to the best of the authors' knowledge no review of the literature exists on digital innovation in entrepreneurial firms. Kraus et al. (2018) provided a qualitative literature review of "digital entrepreneurship" by analyzing 35 works. They identified the following six topics: digital business models; digital entrepreneurship process; platform strategies; digital ecosystems; entrepreneurship education; and social digital entrepreneurship. Satalkina and Steiner (2020) carried out an analysis of 52 papers with the aim of systematizing the determinants of digital entrepreneurship within three dimensions of the innovation system: the entrepreneur's profile; the entrepreneurial process; and its relevant ecosystem. A systematic literature review (SLR) on a sample of 39 high-quality papers on digital transformation was performed by Kraus et al. (2021) in which works were classified according three main clusters dealing with the societal, business, and technological impact of digital transformation. Di Vaio et al. (2021) investigated the role of digital innovation according to a knowledge-based perspective through a bibliometric analysis of 46 papers. Ramdani et al. (2021) provided a SLR on digital innovation in SMEs, analyzing 382 articles to provide a theoretical framework of digital innovation in SMEs based on three main components: digital innovation antecedents; digital innovation processes; and digital innovation performance.

The main contributions in past special issues and reviews are summarized in the Appendix. Although these works provide a useful summary of specific aspects related to the theme of this study, none of them address systematically the topic of entrepreneurial firms and digital innovation together. Because of the lack of such a synthesis,

obtaining an overview of this fragmented domain can be difficult. This is the first systematic review article to specifically address the two topics together, aiming to provide a comprehensive/integrated analysis exploring the topics, trends, methods/variables, and constructs used in prior studies integrating digital innovation, entrepreneurship, and new business ventures perspectives.

This study provides a state-of-art synthesis of scholarly research published over the past 20 years in the innovation and entrepreneurship field of study in order to provide a systematic mapping of the theoretical insights and knowledge gaps present in existing research. Furthermore, it suggests promising paths for future research on the intersection between digital innovation, entrepreneurship, and new business ventures. To achieve this goal, we used a combination of techniques. We performed bibliometric analyses aimed at understanding the main research trends (e.g. overall number of papers published, research methods used, and citations trend). The bibliometric part of the study includes a qualitative bibliometric analysis on the authors' co-citation networks using VosViewer, with the aim of identifying the main cluster of authors that have published in this field (Van Eck and Waltman 2014). The main analysis, however, is based on a text-mining approach, applying latent Dirichlet allocation (LDA) with the support of MySLR software (Ammirato et al. 2022a). This analysis allowed us to identify the main topics in the literature related to digital innovation in entrepreneurial firms.

The main result is the identification and discussion of six topics characterizing the investigated research domain. These topics are:

1. *Start-ups' collaboration networks*, comprising studies considering how an entrepreneurial firm relations impact digital innovation.
2. *Business-model innovation*, comprising studies on the relationship between digital innovation and business models in entrepreneurial firms.
3. *Digital platforms*, which have emerged as a particularly relevant type of digital technology in recent works.
4. *Digital ventures*, comprising papers focusing on the internal characteristics of the new firms.
5. *The digital entrepreneur's profile*, comprising, instead, papers focusing on the characteristics of the entrepreneur.
6. *Digital-innovation ecosystems*, comprising studies that adopt a broader perspective of the system of actors participating in digital innovation processes.

By analyzing the papers clustered into these topics, we provide an integrated view of this knowledge domain and identify research limitations and gaps. Based on this analysis, we provide an agenda for future research.

2 Methodology

We carried out a SLR (Kraus et al. 2022) to provide a complete and exhaustive overview of scientific research on synergies between digital innovation and entrepreneurial firms. The methodological approach we adopted consists of three main steps (papers' location and selection, paper analysis, and results presentation), following Denyer and Tranfield (2009). We implemented the research workflow described in Ammirato et al. (2022a).

2.1 Papers' location and selection

We selected Elsevier's Scopus as the scientific database in which to perform our search. Scopus is a comprehensive and relevant database in the managerial field of study (Kraus et al. 2022) and guarantees that a large proportion of articles published in top journals are included in the results (Bhimani et al. 2019). Several papers providing guidelines for systematic reviews of the literature suggest that Scopus is a suitable database for reviews of the literature (e.g. Donthu et al. 2021; Kraus et al. 2022) because it is one of the largest (Bhimani et al. 2019) and at the same time excludes some low-quality, non-peer reviewed documents (Schiederig et al. 2012). As shown in Table 1, we built two sets of keywords encompassing terms related to digital innovation and entrepreneurial firms, respectively.

The search string was structured so that the results contained papers with at least one term from each set in the title, abstract, and keywords; we found 401 works. In order to select relevant papers, we developed the inclusion and exclusion criteria reported in Table 2. These are divided into quality and fit-for-purpose criteria (Zahoor et al. 2020). Quality criteria are aimed at excluding documents that cannot guarantee a certain level of scientific rigor. In particular, following the approach used in several previous studies (Pittaway et al. 2004; Spender et al. 2017; Zahoor et al. 2020), we only considered papers published in peer-reviewed academic journals. Fit-for-purpose criteria are aimed at verifying whether the article content actually matches the purposes of our review. Basically, these criteria allowed us to verify that the title, abstract, or keywords of the selected papers did not include our search words by chance. We introduced the following criteria: the papers must be written in English and published In journals indexed in the subject areas "Business, Management and Accounting," "Economics, Econometrics and Finance," "Computer Sciences," "Social Sciences," "Decision Sciences," or

Table 1 Sets of keywords used in the database research

Field of study	Keywords
Digital innovation	"digital*" AND "innovat*"
Entrepreneurial firms	"entrepreneur*" AND ("firm" or "startup"or "start-up" or "young companies" or "new venture" or "newly-founded business" or "newly-founded companies" or "small and medium enterprise")

Table 2 Inclusion and exclusion criteria

Description	Reason for inclusion	Reason for exclusion	Examples of excluded papers
Fit-for-purpose criteria			
Language	English	Not applicable	Not applicable[1]
	"Business, Management and Accounting", "Economics, Econometrics and Finance", "Computer Sciences", "Social Sciences", "Decision Sciences" and "Engineering"	Not applicable	Not applicable1
Conceptual boundaries	Entrepreneurship understood as starting and managing a new business	Entrepreneurship as an individual ability (synonymous of initiative)	Keane and Chen (2019)
	Digital innovation as the process of adoption or development of new digital technologies	Analysis of specific technologies and their effects on the business rather than the adoption or development process	Makridakis (2017)
Search terms	Boolean logic with regard to Start-ups, large companies and collaboration	Search terms are present in the title, abstract or keywords but the paper does not fit in the conceptual boundaries of this study	Carayannis and Von Zedtwitz (2005)
Quality criteria			
Database	Scopus	Not applicable	Not applicable[1]
Type of documents	Empirical and theoretical articles published in peer reviewed journals	Books, book chapters conference proceedings	Not applicable[1]

[1]The search methods ensure that articles that do not meet the criteria do not appear in the results

"Engineering." We analyzed the title and abstract of each work and assessed their content in relation to the definition we gave for the search terms (i.e. entrepreneurship and digital innovation, or their synonyms) to verify that they matched with the scope of our study (Christofi et al. 2021). After applying the quality and fit-for-purpose criteria, a total of 185 papers matching our inclusion criteria were found. We have not imposed a date limit from which to select items. Indeed, we were interested in the trajectories of the argument from its origin (Donthu et al. 2021). By choosing articles published in peer reviewed journals and discarding articles presented at conferences, as well as working papers and professional publications, we wanted to privilege the accuracy and scientific quality of the contents analysed. This means that potentially relevant contributions, for example published in books, may have been omitted. On the other hand we did not impose limits based on quality ratings, such as those attributed by the Australian Business Deans Council [ABDC] Journal Quality List [JQL] or by the Chartered Association of Business Schools [CABS] Academic Journal Guide [AJG]) to include a larger sample of items (Kraus et al. 2022). The search process, described in Fig. 1, was carried out at the end of December 2021.

2.2 Paper analysis

This phase was devoted to the examination of papers to highlight relationships and common points among them. We cleaned our sample by removing stopwords and other terms (e.g. scholars' affiliation, copyright statements, and nationalities) that could be misleading with respect to our objectives.

We analyzed the resulting sample of papers in two different steps due to the different outcomes we expected. First, we performed a qualitative bibliometric analysis by exploring the authors' co-citation networks (Van Eck and Waltman 2014). This part of the analysis was achieved using VosViewer software (Van Eck and Waltman 2017). This analysis was aimed at identifying the main clusters of authors working on the topic of digital innovation in entrepreneurial firms in order to analyze commonalities in these clusters, such as the common background of the authors or common theoretical approaches to the topic (Rossetto et al. 2018). While the assignment of the papers' authors to clusters was obtained using VosViewer (and, thus, through quantitative methods), the interpretation of the meaning of the clusters is qualitative and based on our analysis of the titles, abstract, and keywords of the papers for each cluster,

Second, we analyzed the sample of papers in order to identify the main topics in the literature related to digital innovation in entrepreneurial firms. This is the main part of our study and was implemented through a text-mining approach, based on LDA using MySLR software (Ammirato et al. 2022a). The LDA technique gives as output k sets of relevant keywords (where each set represent

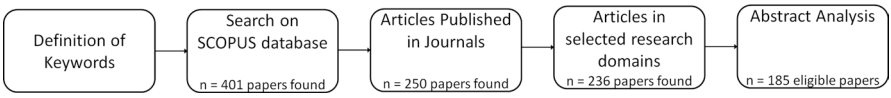

Fig. 1 Papers location and selection process

a topic) and the document-term matrix, i.e. a matrix describing to what extent each paper is devoted to a specific topic (namely, topic proportion). Following Blei (2012), we selected the value of k, i.e. the number of topics to be extracted, by evaluating multiple LDA results with k ranging from 2 to 20, as reported in Fig. 2. We chose the value of k and the LDA algorithm that guarantee a sufficiently high value for topic coherence (Chen and Liu 2014) and, at the same time, a simple interpretation of the results for a human reader. The most meaningful set of topics was reached with $k = 6$, with a u_mass coherence value of -1.70 (Röder et al. 2015) for the Gensim LDA algorithm.

To perform this activity, we used MySLR software (Ammirato et al. 2022a), a semi-automated tool supporting researchers in performing SLRs.

The LDA procedure gave, as output, a group of keywords associated to each topic (as reported in Fig. 3) and a document-term matrix, i.e. a matrix that measures, for each sampled paper, to what extent it is related to each topic (namely the topic proportion). Following the suggestions provided in Grimaldi et al. (2017) and Ammirato et al. (2020b), to deduce meaningful descriptions for each topic, we implemented a human-based review of a restricted, representative, and relevant subset Q of 60 relevant and representative papers. We considered the output of the document-term matrix to identify relevant papers for each topic. The six topics detected through the LDA procedure are presented in Sect. 4. In particular, the description is developed on the basis of the papers' main concepts proposed or a reformulation of the studies they cited.

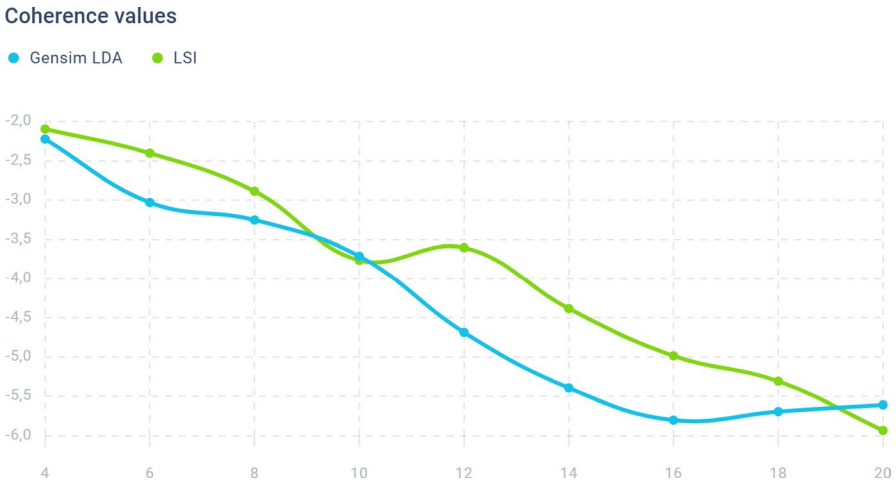

Fig. 2 Coherence scores

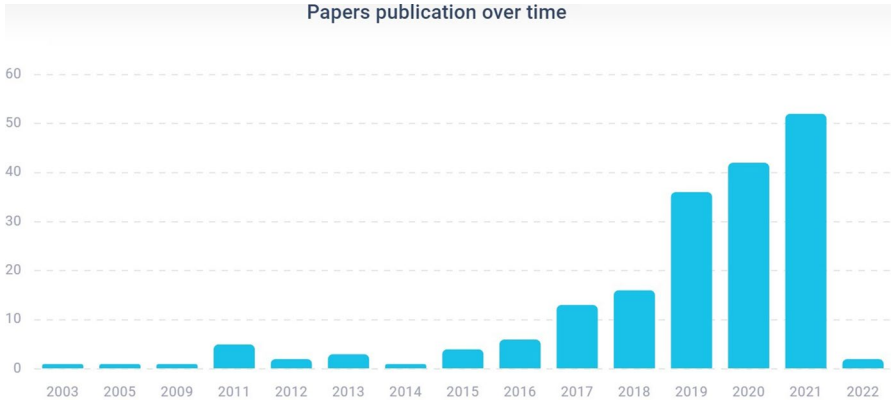

Fig. 3 Published articles by year

3 Results

3.1 Bibliometric analysis

The issue of digital innovation in entrepreneurial firms has become increasingly important over time. Figure 4 shows a growing interest around this theme, starting from 2011. This is a period in which the interest of academia in digital transformation started to grow, as also suggested by previous studies (e.g. Kraus et al. 2021). The growth of papers on the topic of innovation in entrepreneurial firms, however,

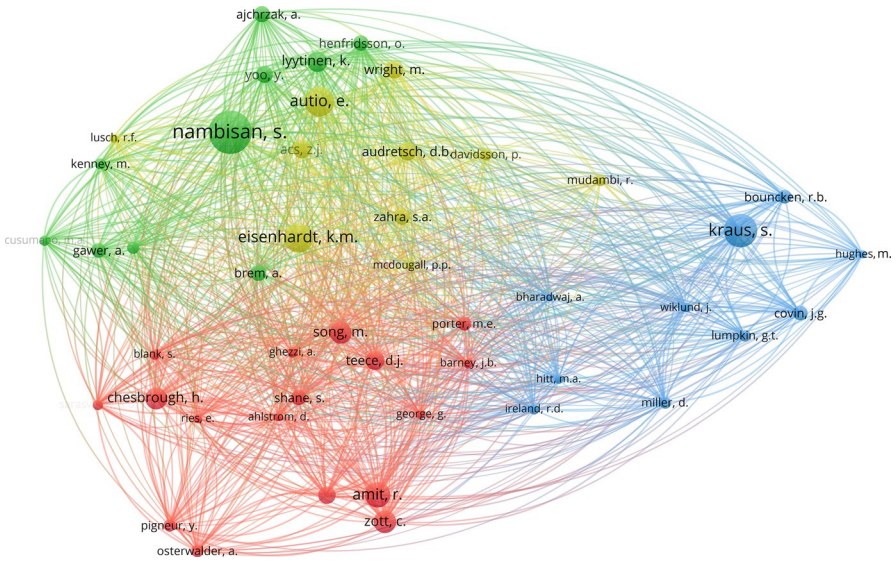

Fig. 4 Published articles by year

has been more accentuated since 2017, with a trend that suggests the domain is exiting its emergent stage (Snyder 2019). About 70% of the papers have been published starting from 2019 and over 50% have been published in the last two years.

We found that the 185 papers in our dataset were published in 121 journals. This demonstrates the high interdisciplinary nature of the issues related to digital innovation and entrepreneurial firms. As presented in Table 3, four journals published six papers or more: *Journal of Business Research*, with the higher number of published papers (9); *Technological Forecasting and Social Change* (8); *Sustainability (Switzerland)* (7); and *Emerald Emerging Markets Case Studies* (6). A total of 23 journals published more than one paper.

The authors' co-citation network (Fig. 5) evidences the presence of four main clusters. Cluster 1 (green) includes authors such as Nambisan (99 local citations), Lyytinen (51), Gawer (34), and Cusumano (25). Cluster 2 (yellow) include authors such as Autio (69), Eisenhardt (68), Audretsch (43), Acs (42), and Davidsson (29). Cluster 3 (blue) includes Kraus (77), Covin (34), and Bouncken (33). Cluster 4 (red) includes Amit (59), Zott (52), Chesbrough (51), Teece (45), Osterwalder (30), Pigneur (29), Blank (24), and Ries (21).

Table 3 Journals with at least 2 articles published in the selected domain

Sources	Articles
Journal of Business Research	9
Technological Forecasting and Social Change	8
Sustainability (Switzerland)	7
Emerald Emerging Markets Case Studies	6
Business Horizons	3
International Journal of Entrepreneurial Behavior & Research	3
Journal of Business Strategy	3
Journal of Information Technology Teaching Cases	3
Journal of Small Business And Enterprise Development	3
Long Range Planning	3
Strategic Entrepreneurship Journal	3
Technology Analysis and Strategic Management	3
Technovation	3
California Management Review	2
Computers in Human Behavior	2
Education and Training	2
International Journal of Advanced Science And Technology	2
International Journal of Innovation And Technology Management	2
International Journal of Innovation Management	2
International Journal of Innovation Science	2
International Journal of Technology Management	2
Journal of Entrepreneurship in Emerging Economies	2
Review of Managerial Science	2

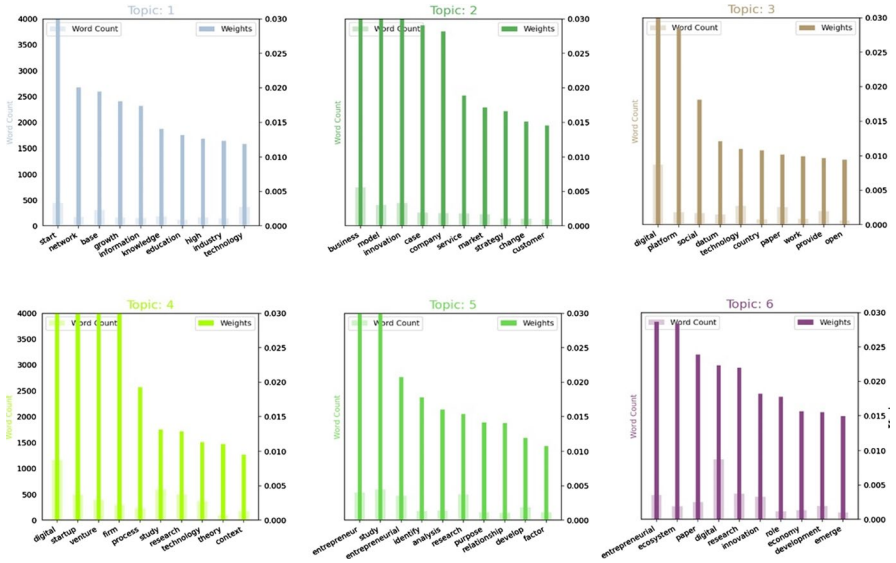

Fig. 5 Word Count

The co-citation network clearly shows the presence of four clusters to which it is possible to associate four theoretical pillars in the area of research analyzed. Specifically, we are able to identify the following theoretical areas of reference that form the basis of the research field of digital innovation in entrepreneurial firms. Cluster 1 (green) deals with the digital technology perspective of entrepreneurship, with authors mainly adopting a digital-technology perspective to analyze the phenomenon at hand. Cluster 2 (yellow) includes studies at the intersection between digital technologies and entrepreneurship. Cluster 3 (blue) mainly adopts an entrepreneurship perspective. Cluster 4 (red) includes researchers involved in innovation-management studies, whose main topics of interest seem to be start-ups and business-model innovation.

We created an inter-topic distance map for our dataset. As presented in Fig. 6, this map represents a visualization of the topics in a two-dimensional space. The area of these topic circles is proportional to the number of words that belong to each topic across the dictionary. The circles are plotted using a multidimensional scaling algorithm based on the words they comprise, so topics that are closer together have more words in common. While topics 1 (start-ups' collaboration networks), 2 (business-model innovation), 4 (digital ventures), and 6 (digital-innovation ecosystems) are close to each other, topics 3 and 5 seem to be quite distant. Topic 3 (digital platforms) includes articles focusing on a specific technology, while topic 5 (the digital entrepreneur's profile) focuses on the individual rather than the organizational level of analysis. The six topics and the differences among them will be discussed in detail in Sect. 3.2.

Focusing on the 60 papers that have been classified as most relevant and representative, reported in Table 4, we observe that one-third of the studies (20) applied

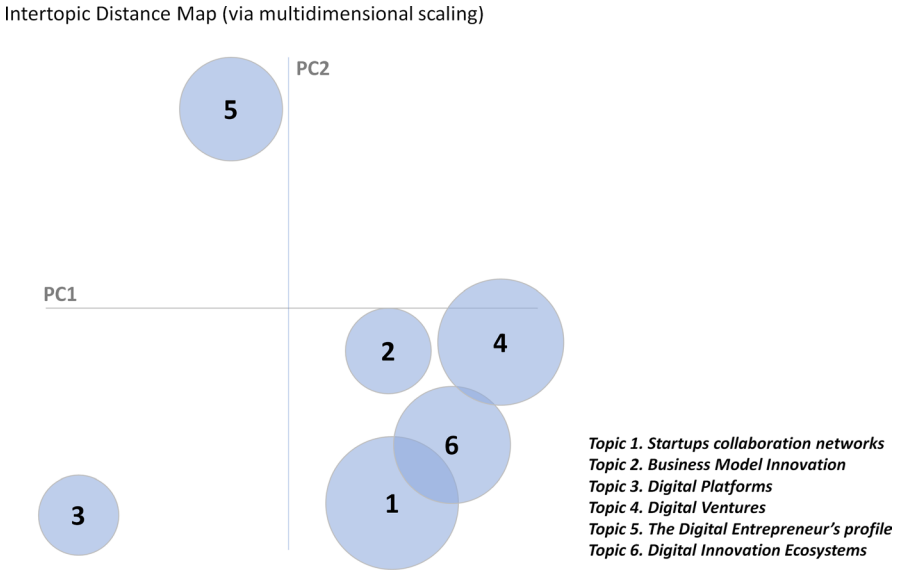

Fig. 6 Intertopic Distance Map

a qualitative methodology (mainly multiple case studies). There were slightly fewer studies based on quantitative methods (15). There is a large number of articles presenting conceptual models (14) without any empirical analysis. Nine papers are reviews of the literature, of which six are systematic reviews. Only three papers present studies based on mixed methods.

As shown in Table 4, the articles analyzed consider a varied set of topics in several different contexts, including different countries, industries, and types of organization (e.g. large companies or SMEs and mature businesses rather than start-ups or spin-off companies).

Finally, the analysis of the most representative and relevant papers made possible the identification of the main research lines, the contexts of applications, the main theoretical references, and the most widely used methodologies. A summary of the results is presented in Table 5.

3.2 Presentation of the main topics

In this section we will discuss the six main topics on which the literature has focused, identified through the LDA approach.

3.2.1 Topic 1. Start-ups' collaboration networks

The creation and maintenance of more or less stable relationships with external partners is decisive for the success of digital start-ups (Teece 2010). SMEs and start-up companies in the digital sector face a lack of resources for innovation. Smallness,

Table 4 List of 60 most relevant and representative papers

Authors	Year	Title	Source	Theory	Context	Content	Methodology
Ammirato, S., Sofo, F., Felicetti, A. M., Helander, N., & Aramo-Immonen, H	2019	A new typology to characterize Italian digital entrepreneurs	International Journal of Entrepreneurial Behavior & Research	Individual-opportunity nexus; entrepreneurial profile	Italian Digital new ventures	Digital entrepreneur's profile	Quantitative analysis
Autio, E., Kenney, M., Mustar, P., Siegel, D., & Wright, M	2014	Entrepreneurial innovation: The importance of context	Research Policy	National Innovation Systems	Digital entrepreneurial firms	Digital Innovation Ecosystem	Conceptual Model
Autio, E., Nambisan, S., Thomas, L. D., & Wright, M	2018	Digital affordances, spatial affordances, and the genesis of entrepreneurial ecosystems	Strategic Entrepreneurship Journal	Entrepreneurial Ecosystems	REGIONAL BUSINESS INCUBATORS	Digital Innovation Ecosystems	Conceptual Model
Bala, H., & Feng, X	2019	Success of small and medium enterprises in Myanmar: Role of technological, organizational, and environmental factors	Journal of Global Information Technology Management	Technology organization-environment framework	SMEs in Myanmar	Digital Ventures; digital entrepreneur's profile	Quantitative analysis
Benoit, S., Baker, T. L., Bolton, R. N., Gruber, T., & Kandampully, J	2017	A triadic framework for collaborative consumption (CC): Motives, activities and resources & capabilities of actors	Journal of Business Research	Collaborative consumption	Digital platform operators	Digital Platforms	Conceptual model

Table 4 (continued)

Authors	Year	Title	Source	Theory	Context	Content	Methodology
Bogers, M	2011	The open innovation paradox: knowledge sharing and protection in R&D collaborations	European Journal of Innovation Management	Transaction cost economics; resource-based view of the firm	R&D Collaboration	Startups collaboration networks	Multiple case study
Bonfanti A., Del Giudice M., Papa A	2018	Italian Craft Firms Between Digital Manufacturing, Open Innovation, and Servitization	Journal of the Knowledge Economy	Open innovation and Servitization	Digitalization in entrepreurial firms	Digital ventures	Multiple Case Study
Boudreau, K., & Lakhani, K	2009	How to manage outside innovation: Competitive markets or collaborative communities?	MIT Sloan Management Review	Collaborative consumption; Open innovation	Digital platform operators	Digital Platforms	Conceptual model
Bunduchi, R., Crișan-Mitra, C., Salanță, I. I., & Crișan, E. L	2021	Digital product innovation approaches in entrepreneurial firms–the role of entrepreneurs' cognitive frames	Technological Forecasting and Social Change	Entrepreneurial Cognitive Frames; perpetual incompleteness of digital products	Small digital entrepreneurial firms	The Digital Entrepreneur's profile; Digital Ventures	Multiple case study

Table 4 (continued)

Authors	Year	Title	Source	Theory	Context	Content	Methodology
Carayannis, E. G., & Von Zedtwitz, M	2005	Architecting gloCal (global–local), real-virtual incubator networks (G-RVINs) as catalysts and accelerators of entrepreneurship in transitioning and developing economies: lessons learned and best practices from current development and business incubation practices	Technovation	Entrepreneurial Ecosystems	REGIONAL BUSINESS INCUBATORS	Digital Innovation Ecosystems	Conceptual model
Cavallo, A., Ghezzi, A., Dell'Era, C., & Pellizzoni, E	2019	Fostering digital entrepreneurship from startup to scaleup: The role of venture capital funds and angel groups	Technological Forecasting and Social Change	Organization growth lifecycle; venture financing	Italian Digital new ventures	Startups collaboration networks	Regression analysis

Table 4 (continued)

Authors	Year	Title	Source	Theory	Context	Content	Methodology
Chalmers, D., Matthews, R., & Hyslop, A	2021	Blockchain as an external enabler of new venture ideas: Digital entrepreneurs and the disintermediation of the global music industry	Journal of Business Research	External enabler theory	Digital entrepreneurial firms in the music industry	The digital entrepreneur's profile	Multiple case study
Chesbrough, H	2010	Business model innovation: opportunities and barriers	Long Range Planning	Open Innovation; Business Model Innovation	Digital spin-offs	Business Model Innovation	Case study; Conceptual Model
Corvello, V., Steiber, A., & Alänge, S	2023	Antecedents, processes and outcomes of collaboration between corporates and start-ups	Review of Managerial Science	Collaboration Models; Organization growth lifecycle	Swedish startups	Startups collaboration networks	Multiple Case Study
Cosenz, F., & Bivona, E	2021	Fostering growth patterns of SMEs through business model innovation. A tailored dynamic business modelling approach	Journal of Business Research	System Dynamics; Business Model Canvas	E-commerce SME	Business Model Innovation	Case study
Day G.S., Schoemaker P.J.H	2016	Adapting to fast-changing markets and technologies	California Management Review	Dynamic capabilities	Digitalization in entrepreurial firms	Digital Ventures	Case Study

Table 4 (continued)

Authors	Year	Title	Source	Theory	Context	Content	Methodology
Dong J.Q	2019	Moving a mountain with a teaspoon: Toward a theory of digital entrepreneurship in the regulatory environment	Technological Forecasting and Social Change	Dynamic Capabilities	Digital entrepreneurial firms	Digital ventures	Case study
Du, W., Pan, S. L., Zhou, N., & Ouyang, T	2018	From a marketplace of electronics to a digital entrepreneurial ecosystem (DEE): The emergence of a meta-organization in Zhongguancun, China	Information Systems Journal	Digital entrepreneurship and ecosystem	Digital entrepreneurial firms	Digital Innovation Ecosystem	Case study
Elia, G., Margherita, A., & Passiante, G	2020	Digital entrepreneurship ecosystem: How digital technologies and collective intelligence are reshaping the entrepreneurial process	Technological Forecasting and Social Change	Digital entrepreneurship and ecosystem	Digital entrepreneurial firms	Digital Innovation Ecosystem	Conceptual model

Table 4 (continued)

Authors	Year	Title	Source	Theory	Context	Content	Methodology
Elia, G., Margherita, A., Ciavolino, E., & Moustaghfir, K	2021	Digital Society Incubator: Combining Exponential Technology and Human Potential to Build Resilient Entrepreneurial Ecosystems	Administrative Science	Entrepreneurial Ecosystems	Digital Incubators	Digital Innovation Ecosystem	Systematic literature review
Ferreira J.J.M., Fernandes C.I., Ferreira F.A.F	2019	To be or not to be digital, that is the question: Firm innovation and performance	Journal of Business Research	Antecedents of Digital Transformation	Portugueses digital firms	Digital Ventures; Business Model Innovation	Multivariate quantitative analysis
Gagliardi D	2013	Next generation entrepreneur: Innovation strategy through Web 2.0 technologies in SMEs	Technology Analysis & Strategic Management	Digital entrepreneurship	Digital entrepreneurial firms	Digital ventures	Quantitative analysis
Gawer, A., & Cusumano, M. A	2014	Industry platforms and ecosystem innovation	Journal of product innovation management	Network Effects and Multisided Markets	digital platform operators	Digital Platforms	Multiple Case Study
Ghezzi, A., & Cavallo, A	2020	Agile business model innovation in digital entrepreneurship: Lean startup approaches	Journal of Business Research	Business Model Innovation; Lean Startup; Agile development	Digital Startups	Business Model Innovation	Multiple Case Study

Table 4 (continued)

Authors	Year	Title	Source	Theory	Context	Content	Methodology
Granstrand, O., & Holgersson, M	2020	Innovation ecosystems: A conceptual review and a new definition	Technovation	Digital entrepreneurship and ecosystem	Digital entrepreneurial firms	Digital Innovation Ecosystem	literature review; multiple Case study
Gupta, G.; Bose, I	2018	Strategic learning for digital market pioneering: Examining the transformation of Wishberry's crowdfunding model	Technological Forecasting and Social Change	Strategic Learning; digital capabilities	Digital Businesses	Digital Ventures; digital entrepreneur'sprofile	quantitative analysis
Haaker, T., Ly, P. T. M., Nguyen-Thanh, N., & Nguyen, H. T. H	2021	Business model innovation through the application of the Internet-of-Things: A comparative analysis	Journal of Business Research	Business Model Innovation	IoT Startups	Business Model Innovation	Multiple Case Study
Hagiu, A. and Wright, J	2015	Multi-sided platforms	International Journal of Industrial Organization	Network effects	Digital multi-sided platforms	Digital Platforms; Business Model Innovation	Mathematical Model
Hair, N., Wetsch, L.R., Hull, C.E., Perotti, V. and Hung, Y.-T.C	2012	Market orientation in digital entrepreneurship: advantages and challenges in a web 2.0 networked world	International Journal of Innovation and Technology Management	Market orientation	Digital Businesses	Digital ventures	Quantitative analysis

Table 4 (continued)

Authors	Year	Title	Source	Theory	Context	Content	Methodology
Hartmann, P.M., Zaki, M., Feldmann, N. and Neely, A	2016	Capturing value from big data—a taxonomy of data-driven business models used by start-up firms	International Journal of Operations and Production Management	Business Model	Big Data Digital Startups	Business Model Innovation	Two step cluster analysis
Hsieh, Y. J., & Wu, Y. J	2019	Entrepreneurship through the platform strategy in the digital era: Insights and research opportunities	Computers in Human Behavior	Open Innovation and Entrepreneurship	digital platform operators	Digital Platforms	Conceptual Model
Hull, C. E. K., Hung, Y. T. C., Hair, N., Perotti, V., & DeMartino, R	2007	Making advantage of digital opportunities: a typology of digital entrepreneurship	International Journal of Networking and Virtual Organisations	Entrepreneurship typology	Digital entrepreneurial firms	Digital Ventures; Business Model Innovation	Conceptual Model
Kamberidou, I	2020	Distinguished" women entrepreneurs in the digital economy and the multitasking whirlpool	Journal of Innovation and Entrepreneurship	Gender attitudes	Female digital entrepreneurs	Digital entrepreneur's profile	Literature Review
Kapoor, K., Bigdeli, A. Z., Dwivedi, Y. K., Schroeder, A., Beltagui, A., & Baines, T	2021	A socio-technical view of platform ecosystems: Systematic review and research agenda	Journal of Business Research	Socio-Technical view	Digital platform operators	Digital Platforms	Systematic literature review

Table 4 (continued)

Authors	Year	Title	Source	Theory	Context	Content	Methodology
Kraus S, Palmer C, Kailer N, Kallinger FL, Spitzer J	2018	Digital entrepreneurship: a research agenda on new business models for the twenty-first century	International Journal of Entrepreneurial Behavior & Research	Digital entrepreneurship	Digital entrepreneurial firms	Business Model Innovation	Systematic literature review
Kuester, S., Konya-Baumbach, E. and Schuhmacher, M.C	2018	Get the show on the road: go-to-market strategies for e-innovations of start-ups	Journal of Business Research	Signaling theory	Digital Startups	Business Model Innovation	systematic literature review
Larios-Hernández G.J	2017	Blockchain entrepreneurship opportunity in the practices of the unbanked	Business Horizon	Traditional unisystemic views for financial inclusion	FINANCIAL BLOCKCHAIN firms	Digital Platforms; Business Model Innovation	Fuzzy-set Qualitative Comparative Analysis
Lin, Y. K., & Maruping, L. M	2022	Open source collaboration in digital entrepreneurship	Organization Science	Collaboration Models; Organization growth lifecycle	Digital Startups	Startups collaboration networks	Quantitative analysis
Mancha, R. and Shankaranarayanan, G	2021	Making a digital innovator: antecedents of innovativeness with digital technologies	Information Technology & People	Entrepreneurial digital competencies; entrepreneurial orientation	Digital entrepreneurial firms	Digital entrepreneur's profile	PLS-SEM

Table 4 (continued)

Authors	Year	Title	Source	Theory	Context	Content	Methodology
Matricano, D., Castaldi, L., Sorrentino, M., & Candelo, E	2021	The behavior of managers handling digital business transformations: theoretical issues and preliminary evidence from firms in the manufacturing industry	International Journal of Entrepreneurial Behavior & Research	Knowledge-Based View	Digital Businesses	Digital Ventures; digital entrepreneur's profile	Multiple Case Study
McAdam, M., Crowley, C., & Harrison, R. T	2020	Digital girl: Cyberfeminism and the emancipatory potential of digital entrepreneurship in emerging economies	Small Business Economics	Entrepreneurship as emancipation	Digital entrepreneurial firms	Digital entrepreneur's profile	Multiple Case Study
Nambisan, S., Siegel, D., & Kenney, M	2018	On open innovation, platforms, and entrepreneurship	Strategic Entrepreneurship Journal	Open Innovation	Digital platform operators	Digital Platforms	Conceptual Model
Ngoasong, M.Z	2018	Digital entrepreneurship in a resource-scarce context: A focus on entrepreneurial digital competencies	Journal of Small Business and Enterprise Development	Entrepreneurial digital competencies	Digital entrepreneurial firms	Digital entrepreneur's profile	Multiple Case Study

Table 4 (continued)

Authors	Year	Title	Source	Theory	Context	Content	Methodology
Nwankpa, J. K., & Datta, P	2017	Balancing exploration and exploitation of IT resources: the influence of Digital Business Intensity on perceived organizational performance	European Journal of Information Systems	Resource based view; dynamic capability	Digital Businesses	Digital ventures	Quantitative analysis
Piaskowska, D., Tippmann, E., & Monaghan, S	2021	Scale-up modes: Profiling activity configurations in scaling strategies	Long Range Planning	Scale-up models	Digital Businesses	Digital Ventures; digital entrepreneur's profile	Quantitative analysis
Pinkow, F., & Iversen, J	2020	Strategic objectives of corporate venture capital as a tool for open innovation	Journal of Open Innovation: Technology, Market, and Complexity	Open Innovation; Ambidexterity	Corporate Venture Capitalists	Digital Innovation Ecosystem	Literature Review
Quinton, S., Canhoto, A., Molinillo, S., Pera, R., & Budhathoki, T	2018	Conceptualising a digital orientation: antecedents of supporting SME performance in the digital economy	Journal of Strategic Marketing	Digital orientation theory	Digital Businesses	Digital Ventures; digital entrepreneur's profile	Conceptual Model
Rachinger, M., Rauter, R., Müller, C., Vorraber, W. and Schirgi, E	2019	Digitalization and its influence on business model innovation	Journal of Manufacturing Technology Management	Dynamic Capabilities; Business Model Innovation	Digitalization in entrepreurial firms	Business Model Innovation	Multiple Case Study

Table 4 (continued)

Authors	Year	Title	Source	Theory	Context	Content	Methodology
Richter, C., Kraus, S., Brem, A., Durst, S., & Giselbrecht, C	2017	Digital entrepreneurship: Innovative business models for the sharing economy	Creativity and innovation management	Sharing Economy; Business Model Innovation	German speaking entrerpreneurial firms in the sharing economy sector	Business Model Innovation; Digital Platforms	Multiple Case Study
Romero, D., & Molina, A	2011	Collaborative networked organisations and customer communities: value co-creation and co-innovation in the networking era	Production Planning & Control	Collaborative Networks	Digital entrepreneurial firms	Digital Innovation Ecosystem	Multiple Case Study
Sambamurthy V., Bharadwaj A., Grover V	2004	Shaping agility through digital options: Reconceptualizing the role of information technology in contemporary firms	MIS Quarterly	Dynamic Capabilities; Business Model Innovation	IT Firms	Business Model Innovation	Conceptual Model
Satalkina L., Steiner G	2020	Digital entrepreneurship and its role in innovation systems: A systematic literature review as a basis for future research avenues for sustainable transitions	Sustainability	Digital entrepreneurship	Digital entrepreneurial firms	Digital Innovation Ecosystem	Systematic literature review

Table 4 (continued)

Authors	Year	Title	Source	Theory	Context	Content	Methodology
Soetanto, D. and van Geenhuizen, M	2015	Getting the right balance: university networks' influence on spin-offs' attraction of funding for innovation	Technovation	Social Capital Theory	spin-offs from technical universities	Digital Innovation Ecosystem; Start-ups collaboration networks	Regression Analysis
Solberg, E., Traavik, L.E. and Wong,	2020	Digital mindsets: recognizing and leveraging individual beliefs for digital transformation	California Management Review	entrepreneurial mindset	Digital Businesses	digital entrepreneur's profile	Conceptual Model
Spender, J.-C., Corvello, V., Grimaldi, M. and Rippa, P	2017	Startups and open innovation: a review of the literature	European Journal of Innovation Management	Open Innovation; Organization growth lifecycle	Startups	Startups collaboration networks; Digital Innovation Ecosystem;	Systematic literature review
Steiber, A., Alange, S., & Corvello, V	2021	Evaluating Corporate-Startup Co-Creation: A Critical Review Of The Literature	International Journal of Innovation Management	Collaboration Models; Organization growth lifecycle	Startups	Startups collaboration networks; Digital Innovation Ecosystem;	Literature Review
Sussan, F. and Acs, Z	2017	The digital entrepreneurial ecosystem	Small Business Economics	Digital Ecosystem	Digital entrepreneurial firms	Digital Innovation Ecosystem	Conceptual Model
Teece, D.J	2010	Business models, business strategy and innovation	Long Range Planning	Business Model	Digital Businesses	Business Model Innovation	Conceptual Model

Table 4 (continued)

Authors	Year	Title	Source	Theory	Context	Content	Methodology
Troise, C., Matricano, D., Candelo, E. and Sorrentino, M	2021	Entrepreneurship and fintech development: comparing reward and equity crowdfunding	Measuring Business Excellence			Digital Platforms	
Zhu, Z., & Lin, S. F	2019	Understanding entrepreneurial perceptions in the pursuit of emerging e-business opportunities: The dimensions and drivers	Computers in Human Behavior	Subjectivist theory of entrepreneurship	Digital Businesses	Digital entrepreneur's profile	Two-stage least square

Table 5 Main Findings

Topic	Main research lines	Main contexts of application	Main theoretical foundations	Main methodological approaches
Startups collaboration networks	Reasons for engaging in collaborative-based innovation initiatives with other digital startups Structural aspects of collaboration Open innovation projects between digital startups and large companies	Digital Startups Academic Spinoffs of technical universities	Transaction cost economics; Resource-based view Social Capital Theory Open Innovation; Organization growth lifecycle Collaborative Networks;	Multiple Case Studies; Literature Reviews Regression Analysis
Business Model Innovation	Performance drivers of business model innovation for digital entrepreneurial firms Novel approaches to business model design as tools to support innovation for digital enterprises	Digital spin-offs Digital businesses Digital companies in specific sectors (e.g. e-commerce, IoT, Big Data, Financial blockchain, sharing economy,…) Digital companies in specific regions (e.g. Italy, Portugal, German speaking countries,…)	Business Model Innovation/ Business Model Canvas System Dynamics Dynamic Capabilities Lean Startup/Agile Development Signaling theory Unisystemic views for financial inclusion	Conceptual Models Case studies/multiple case studies Systematic Literature Reviews
Digital Platforms	Modeling frameworks for digital platforms Digital platforms supporting innovation processes	Digital platform operators Digital platform users Digital platform in specific sectors (e.g. fintech, crowdsourcing, blockchain, and non-fungible tokens)	Collaborative consumption/ sharing economy Open innovation Network Effects and Multisided Markets Socio-Technical view Unisystemic views for financial inclusion Business Model Innovation	Conceptual Models Multiple Case Studies

Table 5 (continued)

Topic	Main research lines	Main contexts of application	Main theoretical foundations	Main methodological approaches
Digital Ventures	Antecedents contributing to the birth of innovation-oriented digital entrepreneurial firms Strategies for digital entrepreneurial firms' success Critical success factors for digital enterprises	Regional Digital Ventures (e.g. Italy, Myanmar,…) Digital entrepreneurial firms in specific industries (e.g. music, tourism) Digital entrepreneurial firms/ digital businesses	Dynamic Capabilities Resource-based view; Knowledge-based view Antecedents of Digital Transformation Market orientation Strategic Learning Intellectual Capital Theory	Quantitative Analysis (Regression Analysis—SEM) Case Studies/Multiple Case Studies
The Digital Entrepreneur's profile	Reasons for starting digital entrepreneurial firms Factors characterizing successful digital entrepreneurs entrepreneurial behaviour and the motivation to start digital ventures the traits of the innovator in the digital environment Gender studies in digital innovation entrepreneurship	Regional Digital Ventures (e.g. Italy, Myanmar,…) Female digital entrereneurs Digital entrepreneurial firms in specific industries (e.g. music, tourism) Digital entrepreneurial firms	Individual-opportunity nexus; entrepreneurial mindset/entrepreneurial profile/Entrepreneurial Cognitive Frames/ entrepreneurial orientation; subjectivist theory of entrepreneurship digital capabilities/entrepreneurialdigital competencies/ digital orientation theory Knowledge-Based View Gender attitudes/Entrepreneurship as emancipation	Quantitative Analysis (Regression Analysis—SEM) Multiple Case Studies

Table 5 (continued)

Topic	Main research lines	Main contexts of application	Main theoretical foundations	Main methodological approaches
Digital Innovation Ecosystems	Contextual aspects of digital innovation ecosystems Performances of digital innovation ecosystems Impact of innovation ecosystems on digital entrepreneurial firms performances Collaboration between digital new ventures and other stakeholders	Regional business incubators Regional Innovation Systems Corporate Venture Capitalists Spin-offs from technical universities	Social Capital Theory Digital entrepreneurship and ecosystems Collaborative Networks Open Innovation	Conceptual Models Systematic Literature Reviews

the structural lack of tangible and intangible resources, and the lack of financial and human resources often limit their ability to develop and market new product and services (Spender et al. 2017). Being involved in collaboration processes is therefore a necessity for start-ups that want to overcome the above-described weaknesses and bring innovative products and/or services to the market (Bogers 2011).

In the innovation literature, collaboration networks are considered as functional in deploying innovative products and services since they help start-ups to acquire resources or to introduce new products into the market (Soetanto and van Geenhuizen 2015). Bunduchi et al. (2021) found that "collaborating with others" represents a valuable solution for digital-entrepreneurial firms that are aiming to acquire development and commercialization capabilities. In particular, they evidenced that collaboration is seen as critical to offer digital entrepreneurs the opportunity to access international markets, which would otherwise be difficult (or impossible) to enter.

Some works have addressed the structural aspects of collaboration, i.e. actors and roles involved in collaborative processes. Soetanto and van Geenhuizen (2015) analyzed the impact of the characteristics of the network (e.g. dimension and density) on the ability of new firms to attract funding. Regarding the actors involved in digital-innovation networks, the analysis of the literature led to the identification of certain categories of actors. Lin and Maruping (2022) analyzed the relationship between the level of engagement in open-source collaboration and the value of digital start-ups. They analyzed a pool of 17,552 digital start-ups to prove how this effect is contingent on the stage of venture maturity (conception, commercialization, or growth) and the mode of engagement (inbound or outbound).

Some research has been devoted to investigating the collaboration between digital start-ups and large companies. Steiber et al. (2021) proposed a framework for evaluating collaboration, based on three main dimension, namely the purpose of the collaboration, time, and the stakeholder perspective. Goncalves et al. (2020) deepened how organizational culture influences company agility and how it enables or hinders digital innovation in start-ups and large firms. They found that the most innovative start-ups were those based on a clan or adhocracy culture, open-minded towards working with external partners, including large firms. Corvello et al. (2023) analyzed the antecedents, processes, and outcomes of collaboration between large corporates and innovative start-ups, including digital ones. They proposed a set of factors that could guide start-ups in evaluating the opportunity for collaboration with large corporates. Relevant factors to take into consideration when start-ups engage in collaboration with large partners are the maturity of the start-up and its technology, the presence of intermediaries, as well as the objectives of the start-up and of the large corporation.

3.2.2 Topic 2. Business-model innovation

The increasing availability of social media technologies, the Internet of things (IoT), and big data analytics has had a huge impact on the deployment of new business models. The anything-as-a-service economy has represented a revolution in the business context over recent years (Rachinger et al. 2019). Within the digital revolution, rather than focusing on the new technology itself, it is important to emphasize

the ability to design and modify (i.e. to innovate) a company's business models in order to boost firms' competitiveness and sustainability (Hagiu and Wright 2015).

Business-model innovation has become a topic of paramount importance in several research fields of study, such as innovation, strategy, and entrepreneurship (Chesbrough 2010; Amit and Zott 2012). Business models in digital settings possess distinctive characteristics compared to traditional ones (Hull et al. 2007). Kuester et al. (2018) explored how digital entrepreneurs should design their go-to-market strategies in order to facilitate the adoption of e-innovations. Haggege et al. (2017) investigated the performance drivers of business-model innovation. They highlighted the interdependence of drivers, arguing that the specific combination of these drivers matters at different phases of an entrepreneurial firm's lifecycle.

Some authors have focused on the study of approaches to business-model design in terms of tools to support innovation processes for digital entrepreneurs (Ammirato et al. 2022b). Osterwalder et al. (2010) proposed the well-known business model canvas, widely used to design business models for digital start-ups. Hartmann et al. (2016) provided an exhaustive analysis of the business-modeling framework for digital services. According to Cosenz and Bivona (2021), designing and experimenting with dynamic business modeling in entrepreneurial firms allows entrepreneurs to explore and simulate alternative scenarios. This practice is extremely useful, especially in highly uncertain and dynamic contexts such as that of digital business (Del Giudice et al. 2016).

Digitalization is the backbone for innovating business models in many sectors. Several case-study applications have proved the value of business-modeling approaches in designing innovation for entrepreneurial firms. Ammirato et al. (2022b) proposed the case of a digital entrepreneurial firm offering web services for passenger-transportation companies. They showed how the system-dynamics approach allowed entrepreneurs to overcome the complexity of the business parameters within the design of the business model. Aloini et al. (2022) investigated the relationship between digital technologies and the business-model structure by means of a multiple case study of start-ups operating in the aerospace industry. Haaker et al. (2021) provided an analysis of business models for IoT entrepreneurial firms in Vietnam. Their analysis of the case studies led to the creation of a general IoT business model providing alternatives for each of the four business-model dimensions. Ghezzi and Cavallo (2020) carried out an exploratory multiple case study based on three digital start-ups to design a framework taking into account the relationship between business-model innovation, lean start-up, and agile development, within the context of strategic agility.

3.2.3 Topic 3. Digital platforms

Digitalization has enabled the emergence of web- and mobile-based platforms supporting value creation and innovation in small enterprises' activities and entrepreneurial initiatives (Kapoor et al. 2021). Digital platforms, entrepreneurship, and innovation are tightly intertwined. During the last two decades, digital platforms have proliferated as an engine of innovation for partners to build complementary products and services. The success of digital platforms relies on the important role

of complementary innovators (Boudreau and Lakhani 2009). We have witnessed a growth in digital entrepreneurs supporting digital platforms such as Android, iOS, Facebook, and Twitter. The success of these platforms requires support from applications, and entrepreneurs in such settings play a critical role in making some platforms rather than others succeed (Srinivasan and Venkatraman 2018). According to Gawer and Cusumano (2014), a platform can be defined as a technology that an external innovator uses as a foundation to innovate and develop complementary products. Over the last few years, several platforms have emerged, becoming an inseparable part of our everyday life. Examples of successful digital-entrepreneurial firms include Airbnb, which disrupted the hotel business by launching a new sharing-economy-based platform for accommodation rental (Benoit 2017). Similarly, Uber changed the game in the taxi business by not owning any taxis (Cramer and Krueger 2016). Platforms enable matching among consumers and producers, facilitating the exchange of goods and services, and enabling value creation for all through the digital landscape in multi-sided markets (Parker et al. 2017). Hsieh and Wu (2019) identified three types of platforms, namely innovation, transaction, and integration platforms. The first type deals with platforms providing developers with an environment through which to develop complementary products and services (e.g. the Android ecosystem). The second type favors the meeting between supply and demand, typical of electronic-commerce platforms for products (e.g. Amazon) or services (e.g. Airbnb). Finally, integration platforms offer the capabilities both of transaction and innovation platforms.

A relevant area of scientific literature in the context of strategic entrepreneurship is focusing on how digital-born entrepreneurial firms develop and adapt their strategies and business models when their products and services must be coordinated within digital platforms. Srinivasan and Venkatraman (2018) argued that such types of entrepreneurship must, at least, recognize how entrepreneurs take into account the choice of platforms based on network effects, as well as how they preferentially connect to different platforms based on the dynamic characteristics of the interdependence networks between key actors. In doing so, they proposed moving from a framework of strategic entrepreneurship as autonomous actions towards coordinated actions within a network of influences.

Digital platforms can be traced back to different areas of application, such as passenger transportation, social networks, digital payments, and finance. A type of platform that has received much interest concerns the area of the so-called "sharing economy" (Richter et al. 2017). More recently, works on digital platforms and entrepreneurship have dealt with FinTech (e.g. Troise et al. 2021), crowdsourcing (Nambisan et al. 2018), blockchain (Chalmers et al. 2021), and non-fungible tokens (Chohan and Paschen 2023).

3.2.4 Topic 4. Digital ventures

The role of digital start-ups in fostering innovation processes is widely recognized in the literature (Ghezzi and Cavallo 2020; Mingione and Abratt 2020; Scheuenstuhl et al. 2021).

Many studies on digital innovation and digital entrepreneurship have focused on the firm and organization level (Bharadwaj et al. 2013). Some of these works have investigated the antecedents that contribute to the birth of innovation-oriented digital entrepreneurial firms. Managerial strategies (Sprenger et al. 2017) and digital capabilities (Gupta and Bose 2018) have been recognized as the basis for starting an entrepreneurial path for a digital entrepreneurial firm. Other works have considered factors such as IT capability (Nwankpa and Datta 2017) and IT infrastructure maturity (Zhu and Lin 2019). According to Matricano et al. (2021), organizational culture plays a central role when dealing with digital businesses. Organizational culture represents a fundamental factor for digital companies (Solberg et al. 2020). Quinton et al. (2018) asserted that digital orientation in entrepreneurial firms is driven by a positive appraisal of the value created through digital technologies, given the perceived risks. At the same time, the presence of organizational capabilities, adaptability, and cross-functional integration between marketing and non-marketing functions positively impact the success of activities in the digital domain. Schallmo et al. (2017) analyzed preconditions for the development and implementation of a digital business model, combining them in a transformation roadmap.

These factors are highly relevant, especially in the context of digital innovative businesses, characterized by high dynamism and volatility, with opportunities that emerge and vanish rapidly (Autio et al. 2018).

The definition of appropriate strategies, according to the digital-economy paradigm, is fundamental for entrepreneurial firms' success. Digitalization represents an important enabling factor for strategy deployment both at organizational and employee levels (Le Dinh et al. 2018). Piaskowska et al. (2021) studied digital scale-up companies, discussing scaling strategies based on Penrose's theory of firm growth in the digitization context. Ghezzi et al. (2019) analyzed the adoption of lean start-up approaches by digital entrepreneurial firms launching innovative products/services.

Some works have investigated critical factors contributing to the success of digital entrepreneurial firms. Spiegel et al. (2016) highlighted the importance of social capital, the presence of a balanced and stable team, and organizational agility as crucial factors for company success. Ammirato et al. (2020) identified critical success factors affecting digital companies' ability to pursue entrepreneurial objectives. The ability to obtain funds, to set up an appropriate business plan, and to find reliable and willing partners were recognized among the most relevant factors. Other studies have investigated the organizational and business-process performance of digital entrepreneurial firms. Regarding organizational performance, the most widely used measures are competitiveness, customer satisfaction, profitability, and internationalization (Scuotto et al. 2017; Bala and Feng 2019).

3.2.5 Topic 5. The digital entrepreneur's profile

The digital entrepreneur is a person pursuing new venture opportunities through the exploitation of digital media, the Internet, and other information and communication technologies (ICTs) (Hair et al. 2012). In some cases, the digital entrepreneur stands out for his/her skills as an innovator and vision capabilities; he/she is an individual

who takes the initiative and is predisposed to change, risk, and the acceptance of failure (Kamperidou 2020). The capability of entrepreneurial ventures to bring new products and services to the market by creating and seizing opportunities depends to a large extent on the work and capabilities of the entrepreneur (Cowling and Nadeem 2020). Higher commitment, individual creativity, and flexibility make entrepreneurial firms agile and ready to take up the challenges of innovation, especially in highly dynamic contexts (Sahut and Peris-Ortiz 2014).

A wide range of studies has been devoted to the identification and analysis of aspects characterizing the figure of the digital entrepreneur. Some of these studies have focused on the reasons why entrepreneurs decide to undertake an entrepreneurial initiative in the digital field (Lasso et al. 2019). The analysis of papers retrieved in this domain allows the identification of two fundamental reasons, namely "necessity-based" or "opportunity-driven." In the first case, we refer to individuals pushed into digital entrepreneurship due to negative external forces (e.g. suffering a layoff, economic problems, or difficulty in finding a job) (Block and Koellinger 2009; Kautonen and Palmroos 2010; Fairlie 2013), while in the second case, we refer to entrepreneurs who have the possibility of seizing an opportunity to achieve economic benefits, self-realization, a better position, or personal satisfaction (Hull et al. 2007; Fossen and Sorgner 2021; Modgil et al. 2022). Other works have investigated factors characterizing successful digital entrepreneurs. Such elements deal with the entrepreneur's attitude (e.g. mindset and leadership), the possession of technical and managerial skills, educational paths, personal ties, and professional connections (Scholin et al. 2016; Vey et al. 2017). The chances of success for digital entrepreneurs have been linked to contextual aspects (Dy et al. 2017). Ngoasong (2018) analyzed a theoretical relationship in which context is an antecedent of an entrepreneur's digital competencies (entrepreneurial and technological skills), influencing the willingness to be engaged in a digital venture and his/her post-entry strategic decisions.

Hassan et al. (2020) studied entrepreneurial behavior and the motivation to start digital ventures. The engagement of digital entrepreneurs is classified into four dimensions: social digital entrepreneurship; business entrepreneurship; knowledge entrepreneurship; and institutional entrepreneurship. Ammirato et al. (2019) identified three main clusters among digital entrepreneurs: emerging young; business-focused; and experienced. These clusters vary with the entrepreneurs' background and competence base, motivation, and satisfaction factors. In particular, the second cluster is the one that is characterized by a strong orientation to technologies and innovation.

Some studies have investigated the entrepreneurial aspects relating to the traits of the innovator in the digital environment. The digital domain is rather new and markedly different compared to analog or traditional ones, demanding a different set of traits and skills (Fichman et al. 2014). Mancha and Iyer (2017) identified some characteristics of the digital entrepreneur/innovator, including attitude toward digital, strong online identity, capacity to leverage social networks, innovativeness with technology, ability to experiment, and managerial skills. Later, Mancha and Shankaranarayanan (2021) delved into the antecedents that make an entrepreneur a digital innovator. They found that the possession of digital skills and self-efficacy distinguish a digital innovator while, surprisingly, digital literacy and entrepreneurial

orientation do not relate to the individual's digital innovativeness. Ngoasong (2018) pointed out that entrepreneurs who are able to deploy entrepreneurial digital competencies are more likely to develop innovative digital businesses.

Some papers have addressed gender questions in digital entrepreneurship. Despite the Utopian view held concerning opportunities deriving from the Internet, gender inequalities, already demonstrated in traditional markets, also persist in the domain of digital entrepreneurship (Duffy and Pruchniewska 2017; Dy et al. 2017). McAdam et al. (2020) deepened the emancipatory possibilities offered by digital entrepreneurship for women constrained by social and cultural practices, such as the male guardianship of female relatives and legally enforced gender segregation. They examined women's engagement in digital entrepreneurship in emerging economies with restrictive social and cultural practices. Kamperidou (2020) confirmed that women entrepreneurs continue to face the multitasking whirlpool, work–life conflict, and discrimination also in digital businesses. In conclusion, the study argued that innovation is the first criterion for successful female digital entrepreneurship.

3.2.6 Topic 6. Digital-innovation ecosystems

This topic concerns the study of the contextual aspects influencing the choices, behavior, and performance of innovative entrepreneurial firms operating within the digital domain. Autio et al. (2013) distinguished two types of entrepreneurial-innovation behaviors in web-based companies: "entry behaviors" (i.e. the situational context leading individuals to initiate an entrepreneurial pursuit); and "post-entry behaviors" (i.e. how the context affects entrepreneurs' goal-setting). These behaviors lead respectively to two types of effects through which context may influence digital entrepreneurs, namely selection effects and strategic choice effects. Another classification provided by Autio et al. (2014) identifies categories of factors that influence the context (industry and technology, organizations, society, and institution and policy). These contextual factors can create favorable conditions, constituting a breeding environment for the birth and development of digital-innovation ecosystems (Romero and Molina 2011). Sussan and Acs (2017, p. 58) defined digital an entrepreneurial ecosystem as "a self-organizing, scalable and sustainable system composed of heterogeneous digital entities and their interrelations focusing on interactions among entities to increase system utility, gain benefits, and promote information sharing, inner and inter cooperation and system innovation." Du et al. (2018, p. 2) referred to digital entrepreneurial ecosystems as "the combination of social, political, economic and cultural elements within a region that supports the development and growth of innovative start-ups pursuing new venture opportunities presented by digital technologies." According to Granstrand and Holgersson (2020), digital-innovation ecosystems can be defined as purposeful collaborative arrangements within the digital industry, through which firms combine their efforts into innovative, coherent, and collective customer-facing solutions. In this context, digital-innovation ecosystems help entrepreneurs to generate and deploy new ideas, select and allocate resources, exploit market opportunities, and create legitimacy for innovations (Kraus et al. 2018).

Entrepreneurs value the potential of such digital ecosystems as an environment in which to try out ideas and contribute to digital solutions through a collaborative setting. According to Elia et al. (2020), digital technologies in innovation ecosystems can represent both the object of the venture creation and the context where the operational processes of firms are conducted. In the first case, the digital-innovation ecosystem leverages a network of entrepreneurial knowledge that helps to produce and deliver innovative digital artifacts or services. In the second case, the ecosystem uses digital technologies as a facilitating structure to aggregate a wide network of heterogeneous and geographically dispersed stakeholders in order to deliver innovative products and services. Hsieh and Wu (2019) emphasized the relationship between the way entrepreneurs relate to innovation and their participation in digital ecosystems.

Some works have analyzed the role of incubators in fostering the innovation processes of digital companies. Incubators favor digital-enabled collaboration and offer services such as training, mentoring, access to seed funding, and workspace, offering the opportunity to overcome the resource limitations of a single firm and accelerating the creation of digital offerings and digital start-ups (Elia et al. 2021). These authors proposed a model to identify the actors, values, flows, and processes that are required to support the construction of a resilient digital-entrepreneurial ecosystem.

Other works have examined the collaboration between digital new ventures and business angels and venture capitalists. Cavallo et al. (2019) examined the role of this kind of collaboration in explaining the growth of digital new ventures, with reference to two specific phases of digital start-ups' lifecycle: start-up; and scale-up. They found a positive relationship between venture capitalists' support and the growth of digital ventures, while no evidence emerged for business angels' contribution to digital ventures' growth, both in the start-up and scale-up phase. The role of venture capitalists as a "scout" or as a "coach" for new ventures was investigated by Granz et al. (2021). Venture capitalists are recognized as a powerful support for new ventures to engage in open-innovation practices, since they allow organizations to increase their internal exploitation capabilities and to foster external knowledge acquisition (Pinkow and Iversen 2020).

Some studies have explored how digital-innovation ecosystems arise; for example, Du et al. (2018) analyzed the case of the Zhongguancun digital ecosystem, often referred to as China's Silicon Valley. Based on the meta-organization literature, these authors found that Zhongguancun's ecosystem consists of three roles (institutional supporter, co-working space, and niche players) and two processes (the construction of a common infrastructure and the cultivation of an entrepreneurial culture). Sussan and Acs (2017) introduced a conceptual framework for digital entrepreneurial ecosystems, linking entrepreneurial ecosystems with their focus on agency and institutions, and digital ecosystems with their focus on digital infrastructure and users.

The inter-topic distance map shows an overlap between topic 1 (start-ups' collaboration networks) and topic 6 (digital-innovation ecosystems). In fact, the two topics refer to the relational aspects of digital entrepreneurial firms, both in collaborations aimed at specific objectives (e.g. innovation projects) and with regard to the impact of ecosystems and other stakeholders in the success of digital-innovation projects. Overall, these two aforementioned topics are close in terms of inter-topic distance

with topic 4 (digital ventures) and topic 2 (business-model innovation), since they represent characteristic aspects of digital entrepreneurial initiatives. On the other hand, topic 3 (digital platforms) and topic 5 (the digital entrepreneur's profile) seem to be logically distant from each other and from the other four topics.

4 Discussion

Advancement in digital technologies has led to unprecedented transformation in society and the main economic sectors. Many scholars have recognized the role of digital technologies as a fundamental driver of companies' development and competitiveness (Nambisan et al. 2017; Martínez-Caro et al. 2020). Digital innovation has expanded a wide range of opportunities for entrepreneurs, in terms both of the creation of new digital ventures (Kraus et al. 2019a, b; Nambisan et al. 2019) and as an enabler of transformation for existing businesses (Hanelt et al. 2021). The literature on digital innovation suggests that digital technologies support companies' flexibility (Svahn et al. 2017), lead to market disruption (Geissinger et al. 2020), and offer opportunities for the creation of new business models (Bouncken et al. 2021).

Our study highlights the structure of the literature on digital innovation in entrepreneurial firms and provides insights into the major research topics in this field. The results of the systematic review based on LDA showed that the literature has mainly focused on six main topics, which can be further developed in future research. The first topic, *start-ups' collaboration networks*, highlights the importance of horizontal collaborations for digital innovation and the structural aspects of such collaborations, as well as the open innovation projects between digital startups and large companies. The second topic, *business-model innovation*, examines the drivers of business model innovation for digital entrepreneurial firms and the novel approaches to business model design as a tool to support innovation. The third topic, *digital platforms*, looks at the modelling frameworks for digital platforms and the role of digital platforms in supporting innovation processes. The fourth topic, *digital ventures*, examines the antecedents that contribute to the birth of innovation-oriented digital entrepreneurial firms and the strategies for their success. The fifth topic, *the digital entrepreneur's profile,* looks at the reasons for starting digital entrepreneurial firms, the characteristics of successful digital entrepreneurs, and the impact of the innovation ecosystem on their performance. Finally, the sixth topic, *digital-innovation ecosystems*, focuses on the contextual aspects of digital innovation ecosystems, the performances of these ecosystems, and the impact on digital entrepreneurial firms.

The analysis of the trends, author clusters, and topics has allowed us to identify gaps in the literature and, as a consequence, directions for future research.

A first observation that arises quite clearly from the review and analysis is that digital innovation, with reference to entrepreneurial ventures, is a multi-level phenomenon. The literature passes from the individual level (entrepreneur) to the organizational level (entrepreneurial ventures and business models), to then consider organizational systems of increasing complexity, such as collaborations through digital platforms, networks, and ecosystems as a whole. While studies that focus on one

level of investigation are critical, many dynamics are likely to be better understood if multiple levels are analyzed at the same time. For this reason, we propose that future research includes studies with several units of analysis nested together.

Our analysis suggests a prevalence of studies in the field of entrepreneurship, while studies from the cultural field of innovation management are in the minority. Comparing the results from the text-mining analysis with the theoretical clusters identified in the co-citation analysis, differences and similarities emerge that are worth analyzing. The co-citation analysis identified four groups or clusters of authors that (apart from cluster 2) are associated with specific disciplinary areas, namely technology management, entrepreneurship, and innovation management. The six topics identified through the text-mining approach only partially overlap with the four clusters, but they also seem to represent a mono-disciplinary approach. For example, topics 4 and 5 include entrepreneurship studies (although they not completely overlap with cluster 3). Similarly, topic 3 investigates topics and uses models from the technology-management domain, while topics 1 and 2 often adopt an innovation-management approach. The phenomenon at hand is interdisciplinary, so the contribution of other areas of investigation, in addition to that of entrepreneurship, could be of great value. Thus, a second suggestion for future research is to adopt an interdisciplinary approach, valorizing in particular the field of innovation and technology management.

Furthermore, from the point of view of the theoretical approach, it is noted that the literature addresses the issue of digital innovation with continuity compared to the literature on technological innovation in general. The models used and the referenced theories are very similar to those used for other innovation domains in recent decades, although the phenomena studied are presented as radically different. This happens both for articles that can be placed in the disciplinary area of entrepreneurship and for those in the area of innovation or technology management. The observation can be extended both to articles that study the adoption of new technologies and to those that study their development. A third suggestion for the literature, therefore, is to develop specific theories, constructs, and models for the new context generated by digital transformation.

5 Conclusions

The topic of digital innovation has received great attention from research in recent years. The role of entrepreneurial firms in innovation processes, on the other hand, has been considered central since Schumpeter's contributions. In recent years, however, the intersection between the two fields of research seems to have become broader and deeper. The spectacular success of some digital start-ups in the last quarter of a century and the development of innovation ecosystems centered on new innovative companies have certainly contributed to this phenomenon.

The article provides a descriptive picture of the scientific activity, highlighting the main trends, the most active authors and countries, the journals that have published the most on the topic. This work has mapped the literature published to date

that simultaneously addresses the two themes, relating digital innovation to the role of entrepreneurial firms.

Above all, this paper highlights and analyzes the most frequently addressed thematic areas, namely: start-up'' collaboration networks, business-model innovation, digital platforms, digital ventures, digital entrepreneu''s profile, digital-innovation ecosystems.

These topics provide a roadmap for future research, as there are still gaps in the literature that can be addressed. For example, there is a need for more research that combines different topics to provide a more comprehensive understanding of the digital innovation process in entrepreneurial firms. Additionally, there is a need for more studies that focus on the regional and sectoral differences in the digital innovation process. Furthermore, there is a need for more studies that examine the role of innovation ecosystems in supporting the growth and success of digital entrepreneurial firms. In conclusion, this study provides valuable insights into the current state of the literature on digital innovation in entrepreneurial firms and identifies areas for future research.

The study demonstrates that the research domain is growing and research interest on the topic is lively. However, the results are fragmented. Three main directions have been proposed:

- *Multi-level Analysis* future research should provide a more comprehensive understanding of the phenomenon of digital innovation in entrepreneurial firms at a multiple level, the individual (entrepreneur), organizational (entrepreneurial ventures and business models), and ecosystem levels.
- *Interdisciplinary Approach* research should take into account contributions from other areas of investigation, in particular, the fields of innovation and technology management. By taking an interdisciplinary approach, the digital innovation process in entrepreneurial ventures can be analyzed from multiple perspectives, leading to a more comprehensive understanding of the phenomenon.
- *Development of Specific Theories for Digital Innovation* future research should aim to develop specific theories, constructs, and models for the new context generated by digital transformation. This will provide a more robust understanding of the digital innovation process in entrepreneurial ventures and help to fill the gap between the literature on technological innovation and digital innovation.

The proposed framework is a first step towards a systematization of knowledge on this topic. The relationships between digital innovation and entrepreneurship are numerous and complex. If on the one hand digital innovation is an opportunity for new businesses, on the other hand new entrepreneurial businesses represent a development engine for digital innovation. Not only are they able to contribute to the development of new technologies, but they are able to translate them into business models and test them on the market. Future research will have to analyze the ways in which technological innovation translates into business innovation.

Furthermore, the role of entrepreneurial companies cannot be analyzed in isolation from the ecosystems that have developed thanks to and around digital technologies. These digital innovation ecosystems are made up of a large variety of players (start-ups,

large companies, venture capitalists, intermediaries) linked by a dense network of relationships. The research will have to analyze the phenomenon at several levels a: individual, organizational and ecosystem.

Overall, the article provides a framework for analyzing the phenomenon of innovation in and with entrepreneurial firms that can provide a useful reference for both entrepreneurship and innovation management researchers. It contributes to the advancement of these two disciplines which increasingly interact to explain innovation-related phenomena.

5.1 Implications

The article provides a summary of the topics most frequently dealt with in the literature in the field of digital innovation and entrepreneurship. For this reason, it can be a useful guide for entrepreneurs engaged in digital start-ups. It may also be of interest, however, for those managers of large companies looking for partners in start-ups to accelerate the digitization of their business. Our article provides information to policy-makers interested in promoting open innovation in the digital environment.

For business practitioners, this study can provide a useful reference regarding the role of digital innovation and entrepreneurial traits in new venture initiatives. For scholars, the study can provide a holistic overview of the current research landscape in this field, evidencing research themes and gaps in the extant knowledge and envisaging some promising streams for future research.

5.2 Limitations

Some limitations must be acknowledged. The study considered only one database, namely Elsevier's Scopus. While many guideline papers include Scopus among the most suitable databases for SLRs, a small number of relevant documents may have been missed. Future studies could expand the search to other databases. Further, bibliometric techniques may introduce distortions because of their reliance on formal elements and because the qualitative assertions made as a result of the application of bibliometrics techniques can be quite subjective. Much of the work relies on human-based review and interpretation and is for this reason subject to bias. In other words, bibliometric analysis is quantitative in nature, so the relationship between quantitative and qualitative results can be unclear. For the current state of knowledge, this limit can only be overcome through an onerous effort to analyze the full papers, which can be the subject of future studies. Finally, the choice of articles as the only type of source considered (as well as from one specific database, even though it is one of the largest ones) limits the scope of the research and might have led to the omission of some valuable documents.

Appendix

Recent Special Issues on digital innovation and entrepreneurship

Special issue	Journal	No of. Papers included	References	Main focus
Digital Innovation Management: Reinventing innovation management research in a digital world	MIS Quarterly	6	Nambisan et al. (2017)	New challenges for innovation management due to increasing digitalization in entrepreneurship
The digital transformation of innovation and entrepreneurship: Progress, challenges and key themes	Research Policy	11	Nambisan et al. (2019)	Three main themes in the literature on digital innovation and entrepreneurship: affordance, openness and generativity
Digital innovation and Venturing	Review of Managerial Science	7	Kraus et al. (2019a, b)	Focus on crowdfunding, sharing economy and digital business models
The age of digital entrepreneurship	Small Business Economics	5	Sahut et al. (2019)	Digital value creation perspective
Digital or not—The future of entrepreneurship and innovation	Journal of Business Research	11	Berger et al. (2021)	Digital entrepreneurship and digital innovation

Recent Review Papers on digital innovation and entrepreneurship

Review paper	Journal	No of. Papers analyzed	References	Main contribution
Digital entrepreneurship: a research agenda on new business models for the twenty-first century	International Journal of Entrepreneurial Behavior & Research	35	Kraus et al. (2018)	Six main topics in the literature on digital entrepreneurship: digital business models, digital entrepreneurship process, platform strategies, digital ecosystems, entrepreneurship education and social digital entrepreneurship

Review paper	Journal	No of. Papers analyzed	References	Main contribution
Digital entrepreneurship and its role in innovation systems: A systematic literature review as a basis for future research avenues for sustainable transitions	Sustainability	52	Satalkina and Steiner (2020)	Classification of findings in tthree dimensions of the innovation system: the entrepreneur's profile, the entrepreneurial process, and its relevant ecosystem
Digital Transformation: An Overview of the Current State of the Art of Research	SAGE Open	39	Kraus et al. (2021)	Classification of findings in three main clusters: societal, business and technological impact of digital transformation
The role of digital innovation in knowledge management systems: A systematic literature review	Journal of Business Research	46	Di Vaio et al. (2021)	A knowledge—based perspective on digital innovation
Digital innovation in SMEs: a systematic review, synthesis and research agenda	Information Technology for Development	382	Ramdani et al. (2021)	A theoretical framework of digital innovation in SMEs based on three main components: digital innovation antecedents, digital innovation processes and digital innovation performances

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