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REVIEW PAPER

Hatching start-ups for sustainable growth: a bibliometric review on business incubators

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Abstract

Business incubators hatch start-ups, helping them to survive their early stage and to create a solid foundation for sustainable growth by providing services and access to knowledge. The great practical relevance led to a strong interest of researchers and a high output of scholarly publications, which made the field complex and scattered. To organize the research on incubators and provide a systematic overview of the field, we conducted bibliometric performance analyses and science mappings. The performance analyses depict the temporal development of the number of incubator publications and their citations, the most cited and most productive journals, countries, and authors, and the 20 most cited articles. The author keyword co-occurrence analysis distinguishes six, and the bibliographic coupling seven research themes. Based on a content analysis of the science mappings, we propose a research framework for future research on business incubators.

Keywords Business incubators · Bibliometric analysis · Nascent entrepreneurs · Start-ups

Mathematics Subject Classification 91

1 Introduction

This study explores the tendencies and development of the literature on business incubators. Incubators reduce the risk of start-up failure within their first years (Soetanto and Jack 2016) as they support new ventures by granting them access to

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valuable knowledge and services (Bruneel et al. 2012; Hausberg and Korreck 2020), thus helping them survive the start-up stage (Aernoudt 2004; Soetanto and Jack 2016). This support contains financial consulting assistance, management assistance, general business assistance, professional business assistance, and physical services (Allen and Rahman 1985) but also equipped working space and networking possibilities with other entrepreneurs and managers (Peters et al. 2004). Incubators create jobs, "local income" (Markley and McNamara 1995, p. 14), and (technological) innovations (Colombo and Delmastro 2002).

Due to their high practical relevance, incubators have drawn strong attention among researchers (Husberg and Korreck 2020). Research on business incubators has addressed many partial research questions, such as: What target group do incubators address as tenants? What are the functions of incubators relating to entrepreneurship and innovation? What role do universities play as providers of incubators? How are incubators structured? What are the factors influencing incubator and, hence, start-up performance? What are the theoretical foundations of incubator research? Due to the increasing proliferation of the literature, the research field of incubators has become fragmented and somewhat unsystematic. To address this problem, our study aims to organize and integrate the scholarly knowledge base relating to incubators and to explore the main antecedents and characteristics of incubators as well as their impact and performance. To this end, we conduct a bibliometric analysis that is commonly used for reviewing a particular research field (Mongeon and Paul-Hus 2016) and for providing an overview of previous research (Guo et al. 2019). This bibliometric analysis can also be useful for practitioners who require information on what implications business incubators can have on new ventures or regional development. Differing from literature reviews, which represent a qualitative approach, bibliometric analyses are quantitative methods (Zupic and Cater 2015) and, therefore, are considered to be more objective (Chubin and Garfield 1980; Marx and Bornmann 2016). According to Kraus et al. (2020), computer-based data analysis of literature allows for more objective results in a literature review. In particular, the analysis of citation counts allows to evaluate the impact of research units, such as journals, countries, and individual authors (McBurney and Novak 2002). Due to their different foci, bibliometric analyses do not replace but complement literature reviews (Zupic and Cater 2015).

Following Nyons et al.'s (1999) distinction, we conduct both performance analyses and science mappings. While performance analyses examine the literature and publishing practice of researchers and organizations, science mappings seek to uncover the body and dynamics of a research field (Zupic and Cater 2015). The performance analyses aim to reveal the most productive and most impactful articles, authors, journals, disciplines, and countries. With the conducted science mappings, in particular, a keyword co-occurrence analysis and a bibliographic coupling, we visualize hidden structures and reveal research themes within the field. This visualization aims at reducing the complexity of the research topic, thus improving an overall understanding of the field of business incubators (Rodrigues et al. 2014).

Our bibliometric review contributes to business incubator research by identifying previous predominant research themes and by providing a systematic and integrative overview of the research field. Additionally, we inform practitioners and policy

makers about existing possibilities for business incubation support. Our research framework presents an integrative picture of the current knowledge base, offering a quick and comprehensive overview of what is known about business incubators.

The remainder of the paper is structured as follows: In Sect. 2, we provide different definitions of the term "business incubator" and appreciate past literature reviews on the topic. In Sect. 3, we outline the methodology and especially the process of data collection. Section 4 depicts the results of the performance analyses and science mappings. In Sect. 5, we discuss the main findings. Based on the science mappings, we propose a research framework for future research in Sect. 6. A summary and the discussion of the limitations conclude the paper.

2 Concept and past reviews

Despite the lack of a standard definition, most incubator scholars share a common understanding of an incubator as a supporting institution for nascent ventures (Hausberg and Korreck 2020). According to Markley and McNamara (1995), early stage ventures can receive office space, expert services, and other likewise business support from incubators at comparably low costs. Aernoudt (2004) describes business incubators as nurturers for new ventures in their most weak and difficult period, by giving them the opportunity to outlast and evolve. Incubators are places where enterprises are hatched (Aerts et al. 2007).

Business incubators have to be distinguished from several other entities also providing support for start-ups. First, coworking-spaces are partly similar to business incubators as they offer office and social space facilitating personal interactions (Appel-Meulenbroek et al. 2020; Bouncken and Reuschl 2018; Bouncken et al. 2021; Rese et al. 2021) and fostering innovative behavior (Hughes et al. 2018), also to start-ups (Bouncken et al. 2020; Barwinski et al. 2020). However, coworking-spaces are also used by individuals not necessarily involved with start-ups, such as freelancers or employees with incumbent firms (Bouncken et al. 2018). Among other advantages, sharing space contributes to sustainable entrepreneuership (Fennhofer et al. 2014; Oswald and Zhao 2020). Second, science or technology parks also share some analogies as they are commonly defined as "an innovation-related infrastructure through which knowledge is exchanged, and a university is often a catalyst for that symbiosis" (Hobbs et al. 2017). However, their target group is not limited to start-ups as they also offer their services to more established firms (Bergek and Norrman 2008; Hausberg and Korreck 2020; Mian 1996). Third, accelerators, which also have been addressed in previous reviews on business incubation (Hausberg and Korreck 2020), represent an umbrella term for various mentorship, networking, and funding programs (Pauwels et al. 2016). Due to the overlap between these concepts, previous reviews have employed a more general focus on various institutions supporting start-ups. For example, Hausberg and Korreck (2020) make no distinction between accelerators and incubators. Mian (2016) reviews the literature steam on business incubation by relating to technology parks, accelerators, and business

incubators. Hence, a narrow focus on business incubators as an idiosyncratic type of start-up support is missing and our study aims at closing this gap.

Networking is another important component of the incubator concept (Soetanto and Jack 2016). As Hackett and Dilts (2004) point out, a business incubator is also a system of connections between individuals, such as supervisors, tenants, councils, and others. In that sense, a business incubator provides relationships within and outside (Mian 1996). Peters et al. (2004) stress that a business incubator provides "a network of business and technical advisors (…) in finance, business planning, marketing, legal consulting, manufacturing, etc."

Different types of incubators can be distinguished. According to Grimaldi and Grandi (2005) business incubators can be classified into four categories, depending on the operator: business innovation centers, university business incubators, independent private incubators, and corporate private incubators. In contrast, Aernoudt (2004) focuses on the function and considers five types of incubators: mixed incubators, economic development incubators, technology incubators, social incubators, and basic research incubators.

According to Hausberg and Korreck (2020), one of the earliest literature reviews on business incubators was conducted by Campbell and Allen (1987). The authors focus on the development of incubators over time and frameworks on incubator improvement. Markley and McNamara (1995) highlighted the key role of an experienced manager when evaluating incubator success and analyzed effects of incubators on the economy, such as job creation and increased profits. Hackett and Dilts (2004) classified the five mostly analyzed topics relating to incubators: incubator development studies, incubator configuration studies, incubatee development studies, incubator-incubation impact studies, and theorizing about incubator-incubation. They also stress that most studies in the past had a main focus on the structure of an incubator rather than the tenants and their work (Hackett and Dilts 2004). The review by Mian et al. (2016) identified ten diversified theoretical lenses, used from scholars through years of research, such as new venture creation, market failure, the resource-based view, the stakeholder view, structural contingency theory, social network theory, real options theory, dyadic theory, institutional theory, mechanisms-driven theory, and virtual incubation view. In addition, the evolution of incubators in the last 30 years, a bibliometric analysis (covering top journals, most cited studies, etc.) and a highlight on the uprising concept accelerator were also included. Lastly, Hausberg and Korreck (2020) identify studies on origins, definitions and typologies of incubators, studies on incubation processes, and studies on their impact and performance.

3 Methodology

3.1 Bibliometric analysis

Pritchard (1969, p. 349) characterizes bibliometrics as "the application of mathematics and statistical methods to books and other media of communication." Broadus (1987) suggests that bibliometrics is research concentrated on quantity, measuring

numerous released literature collections, or collections of literature analytics, or representatives of both. The author also defines what type of data can be used for carrying out bibliometric analyses, thus giving a narrower definition of the term. Daim et al. (2006) depict bibliometrics as an aid to the investigation, management, and research, on extensive data, and as an assisting tool for scientists for new discoveries (Daim et al. 2006). Van Leeuween (2004, p. 374) describes bibliometrics as "the field of science that deals with the development and application of quantitative measures and indicators for sciences and technology, based on bibliographic information". In other words, large-scale examinations on written studies can be performed with the help of bibliometric methodology (Ellegard and Wallin 2015).

Aimed at a clear depiction of the literature on incubators, several performance analyses and science mapping analyses were performed in this study. As bibliometric analyses can demonstrate the common output, or productiveness, in a specific field, they can as well classify the outcome of certain units, such as authors, journals, regions and others (Andres 2009). Thus, the following three categories of performance analyses were carried out. The first part gave a macro-overview of the field, outlining the number of publications per year, the citations distribution per year and the twenty publications with the most citations on average per year. Then, further analyses revealed the disciplines, journals, countries and authors with the most citations and the most publications, presenting the micro-perspective of the field. Such citation analyses can outline approximately the significance of the indicator (author, journal, etc.) being evaluated (Zhao and Strotmann 2015).

As Small (1999) states, data visualization has the function of giving clear body or structure, in a certain field. Thus, with the purpose of structuring and giving an up to-date depiction of the field of incubators, two science mapping analyses were implemented. Those are: keyword co-occurrence and bibliographic coupling analysis. In this manner, creating visual maps based on citations is not only beneficial when presenting the outcome of citation studies, but it can also be the instrument introducing the undiscovered (Zhao and Strotmann 2015). In particular, bibliographic coupling examines the connections between articles (Wallin 2005). We used the VOSViewer as a visualization tool (Bankar and Lihitkar 2019; Van Eck and Waltman 2020).

3.2 Data collection and cleansing

Citation reports were obtained from the Core Collection of the Web of Science. The database provides access to the earliest published documents and collections from the year 1900 (Falagas et al., 2008), which makes it "the longest-running citation index" (Finch 2012, p. 246). In comparison, the directory Scopus covers research starting in 1996 (Falagas et al. 2008). Since the first publication on incubators was published in 1987 (according to Web of Science), choosing Web of Science as the database for collecting the citation data expanded this research by nine years. The Web of Science is the most used and most important database for bibliometric analyses (Hota et al. 2020; Jappe 2020: Zupic and Čater, 2015) due to its broad coverage of publications in prestigious journals (Adriaanse and Rensleigh.

2013) in the social sciences (Norris and Oppenheim 2007). It is not essential to cover all available publications for bibliometric analyses based on large publication datasets because it is sufficient to use a representative partial sample. For example, when using citation thresholds, large parts of the original dataset are removed from the analyses anyway. Therefore, we decided not to include other databases, such as Scopus or Google Scholar, because including more databases does not tend to produce better results (Harzing and Alakangas 2016).

We first conducted a title search using the search term "incubator*", resulting in 1,844 publications. We examined the publication period from the first publication in the dataset, from January 1987, to December 2019. The year 2020 was excluded from the period as this study was conducted in August 2020 and the year was not full by that time. In the meantime, the publication numbers have further increased. In 2020, another 133 publications were added, and up to August 2nd, 2021, 72 further papers were published.

Searching in the title ensures that articles are more related to our scope, which is why it is commonly practiced in bibliometric studies (Kalantari et al. 2017; Kraus et al. 2014). Additionally, the topic search in the Web of Science also includes so-called "Keywords Plus", which are algorithmically added by the database based on high occurrences in the papers reference lists. As references do not only center around a paper's topic but also include many side aspects, the search results would become much fuzzier. We narrowed the dataset by focusing on the categories "business" and "management" because "incubators" is a widely used term in many disciplines, such as agriculture, pediatrics, cell biology, etc., where it has different meanings. The dataset was further limited by including only papers written in the scholarly "lingua franca" English. We included the document types "article" and "review", as this is the common practice in bibliometric studies in business and management (Merigo et al. 2016; Merigo and Yang 2017). We excluded book chapters and proceeding papers as rigor review processes are not ensured. Thus, the results were narrowed down to 200 papers. After a carefully reading the abstracts of all papers, further five papers were excluded, because, despite having the word "incubator" in the title, the articles did not focus on this topic. One duplicate was removed. Therefore, the final dataset contained 194 documents. Figure 1 summarizes the data collection and cleansing process.

4 Results

4.1 Performance analyses

Figure 2 shows the number of documents and the year of publication. According to Web of Science the first (and the second) article was dating from 1987, hence this is the starting point of this analysis, with 2019 as the endpoint. Looking at the annual differences in publication numbers published per year, the evolution of publication may be separated into three periods (Alayo et al. 2020; Ellegaard and Wallin 2015): 1987–2004, 2005–2010, and 2011–2019. The first period is stable on a low level, with a slight fluctuation between none and four publications. A moderate increase

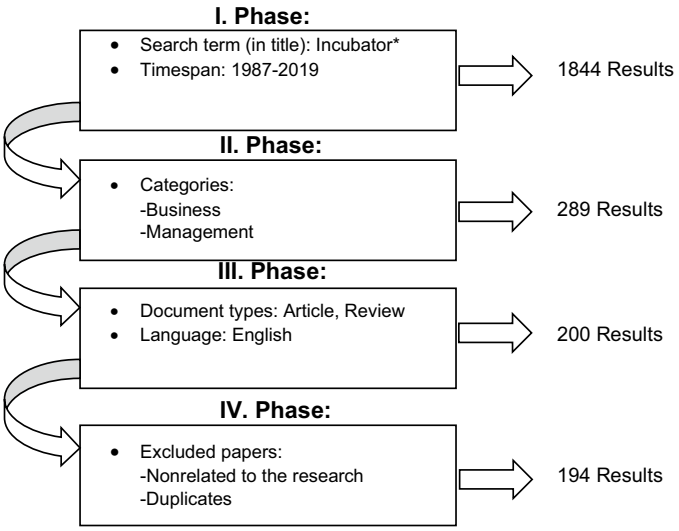

Fig. 1 Data collection process. Source: Own elaboration

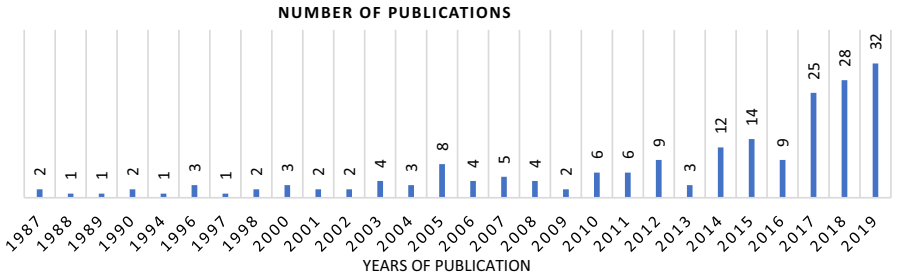

Fig. 2 Number of Publications per Year. Source: Own elaboration based on Web of Science

is marked at the beginning of the second stage in 2005, with eight publications, followed by variation till the end of the period. The third span is inconsistent. Two dips, in 2013 and 2016 can be seen. However, from 2017 till 2019 the number of publications has significantly grown, with the highest point in 2019.

Figure 3 presents the number of citations the publications, which focused on incubators have received. One year after the first publication, in 1988, occurred the first citation. The next 12 years were marked with lower citation count, whereas the highest number is 6 citations in 1997 and 1999. After the year 2000, the distribution of citations began to slowly rise. Apart from 2006 and 2015, where the citation count has fallen, after the year 2000 a gradually increase of the distribution of citations was noticed.

Tables 1 and 2 are concentrated on the most cited journals and the journals with the most publications. After applying the criteria in Web of Science, a total of 99 journals were analyzed in this study. Table 2 shows the most cited sources within the

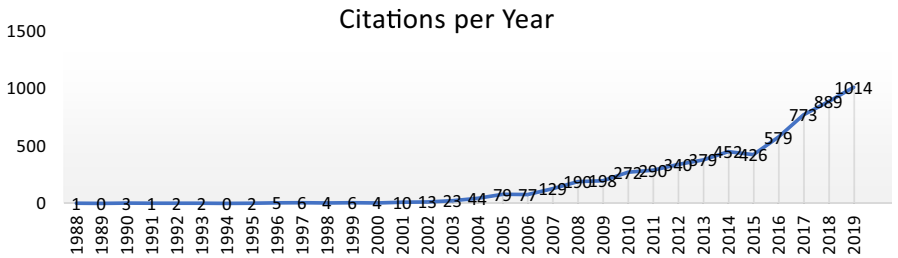

Fig. 3 Distribution of Citations per Year. Source: Own elaboration based on Web of Science

Table 1 Top Ten Journals with Most Citations

Rank	Journal	#Citations
1	Technovation	2,003
2	Research Policy	1,006
3	Journal of Business Venturing	660
4	Journal of Organizational Behavior	426
5	Journal of Technology Transfer	278
6	Journal of Business Research	272
7	Small Business Economics	207
8	Harvard Business Review	174
9	Journal of Small Business Management	166
10	International Small Business Journal	131

Source: Own elaboration based on Web of Science

Table 2 Most Productive Journals (> 3 Publications)

Rank	Journal	#Articles
1	Technovation	21
2	Journal of Technology Transfer	12
3	R & D Management	7
4	Journal of Business Research	6
4	Research Policy	6
5	Entrepreneurship and Regional Development	5
5	International Journal of Innovation	5
6	International Journal of Innovation Management	4
6	International Journal of Technology Management	4
6	Journal of Business Venturing	4
6	Journal of Organizational Behavior	4
6	Journal of Small Business Management	4
6	Technology Analysis Strategic Management	4

Source: Own elaboration based on Web of Science

Table 3 Most Productive Countries (> 5 Articles)

Rank	Countries	#Articles
1	USA	44
2	England	19
3	Italy; Spain	15
4	Brazil	13
5	Germany	11
6	Netherlands; Peoples Republic of China	10
7	Sweden	9
8	Denmark; India	8
9	Belgium; Norway; Canada	7
10	Australia; Malaysia; South Africa	6

Source: Own elaboration based on Web of Science

Table 4 Ten Most Cited Countries

Rank	Countries	#Citations
1	USA	2575
2	Italy	625
3	Belgium	603
4	Netherlands	488
5	England	443
6	Sweden	433
7	Denmark	329
8	Germany	248
9	North Ireland	243
10	Spain	239

Source: Own elaboration based on Web of Science

time span of 1987–2019, with *Technovation* being ranked first with 2003 citations, followed by *Research Policy* with 1006 citations, and *Journal of Business Venturing* in third place with 660 citations. With the intention of identifying the most productive journals publishing in the area of interest, Table 3 lists journals with at least 4 publications in the field of incubators. *Technovation* is positioned first in this analysis as well, as a result of having 21 publications. *Journal of Technology Transfer* is ranked second with 12 publications, followed *by R & D Management* with 7 publications.

The most productive countries are listed in Table 3 and the ten countries with the highest number of citations are presented in Table 4. A total of 48 countries contributed to the field. According to the files downloaded from Web of Science, six records do not contain data about the country they come from. Some of the documents belong to more than one country. Since there are countries with the same number of articles (like Italy and Spain with 15 articles each), these countries share the same ranking position (in this case Italy and Spain are both in third place). The case is different in Table 5 where each country has its own rank. The most

Table 5 Most Productive Authors (> 2 Publications)

Author	Organisation	#Articles
Baskaran, A	Universiti Malaya	4
McAdam, M	Dublin City University	4
Aaboen, L	Norwegian University of Science & Technology	3
Friel, T	Doctus Inc	3
Matthyssens, P	University of Antwerp	3
Mian, S.A	State University of New York—OSWEGO	3
Schwartz, M	Leibniz Institut fur Wirtschaftsforschung Halle	3
Tang, M.F	Chongqing University	3
Vukotich, G	n.d	3

Source: Own elaboration based on Web of Science

productive country (Table 4) is the US with 44 publications, followed by England with 19, Italy and Spain with 15, and Brazil in the fourth position with 13 articles. The first position in Table 5 is also taken by the US, with a total of 2575 citations. Italy is the second most cited country in this dataset with 625 citations and Belgium is third with 603 citations.

Of all 414 authors analyzed in this research, 55 have published more than one article, while less than 10 have produced at least three publications. Table 5 shows the most productive authors, where the maximum number is four publications. The authors Baskaran and McAdam are the most productive researchers in the field of incubators, with four publications each. Another point of interest, when considering the authors in the field, is the citation count they have obtained. Such information

Table 6 Most Cited Authors

Author	Organisation	#Citations
Mian, S.A	State University of New York—OSWEGO	529
Rothaermel, F.T	Georgia Institute of Technology	325
Thursby, M	Harvard University	325
Bollingtoft, A	Aarhus University	302
Colombo, M.G	Polytechnic University of Milan	282
Delmastro, M	Autor Garanzie Nelle Comunicaz	282
Bergek, A	Chalmers University of Technology	268
Norrman, C	Linkoping University	268
Rathinho, T	IESEG School of Management	255
McAdam, M	Dublin City University	243
Ulhoi, J.P	Aarhus University	240
Grimaldi, R	University of Bologna	232
Grandi, A	University of Bologna	232
Mattyssens, P	University of Antwerp	221

Source: Own elaboration based on Web of Science

is presented in Table 6. Mian is the author, who received the highest number of citations—a total of 529, followed by Rothaermel and Thursby with both acquiring 325 citations each. Tables 6 and 7 are also informing on the organization which the author is part of.

Table 7 presents the top twenty articles with the highest sum of citations in average per year. Out of the 20 articles, eight were published in the journal *Technovation*. The highest average citation count per year is 22.33, while the lowest average citation count in the top twenty articles is 9.24. Among 194 publications, first is the article from Bergek and Norman, accumulating 22.33 citations in average per year, with a total citation count of 268, from the year it has been published (2008) to 2019. Ranked second, but as well as the publication in first place, Bruneel et al. (2012) published in *Technovation*, obtaining 20.13 citations in average per year.

4.2 Science mapping

4.2.1 Author keyword co-occurrence analysis

Figure 4 visualises the co-occurrences of author keywords downloaded from Web of Science. The co-occurrence means that two or more keywords are used in the same article. If the same keywords co-occur in the documents, their meaning is closely related (Zupic and Čater 2015). The higher is the frequency of co-occurrence, the stronger is the relation between focal keyword. According to this principle the visual network is created.

The dataset of 463 keywords was limited to a minimum number of three occurrences, whereas 31 items met the threshold. In order to reduce the number of terms with the same meaning, but different spelling or substitutes of the same word (Van Eck and Waltman 2020), a thesaurus file was applied as well. Labels written differently, for instance, "start up" and "start-up", along with synonyms labels, were merged together. Items with plural labels such as "business incubators" or "firms" were replaced by their singular form as well. The keywords "incubator" and "business incubator" (singular and plural) were also merged into one keyword in the thesaurus file, namely "business incubator" since they are synonyms. The full counting method was selected for this analysis. In Fig. 4, the weight being visualized is the occurrence. When a keyword has a greater weight than another, its label and bubble are bigger than a keyword with lower weight (Van Eck and Waltman 2020). Therefore, bigger bubbles indicate a keyword with a higher number of occurrences in the publications.

Six clusters with 98 links occurred. To describe the clusters, we provide the examples of the most prominent and most cited papers represented in each cluster. The clusters can be described as follows:

1. Red Cluster: *Business Incubator and Entrepreneurship*: The biggest cluster consists of 8 items. The keyword with most occurrences – 22 times, is "entrepreneurship". Other keywords of interest in this cluster are "regional development" and "economic development", with both terms occurring three times each. This cluster can be represented by Monsson and Jørgensen (2016) who suggest that diverse

Table 7 The Top 20 Articles with Highest Average Citations per Year

Rank	Title	Authors, year of publication	Journal	Total citation count	Average citations per year
1	Incubator best practice: A framework	Bergek and Norrman (2008)	Technovation	268	22.33
2	The evolution of business incubators: Comparing demand and supply of business incubation services across different incubator generations	Bruneel et al. (2012)	Technovation	161	20.13
3	The networked business incubator—leveraging entrepreneurial agency?	Bollingtoft and Ulhoi (2005)	Journal of Business Venturing	240	16
4	How effective are technology incubators? Evidence from Italy	Colombo and Delmastro (2002)	Research Policy	282	15.67
5	Business incubators and new venture creation: an assessment of incubating models	Grimaldi and Grandi (2005)	Technovation	232	15.47
6	Critical role and screening practices of European business incubators	Aerts et al. (2007)	Technovation	167	12.85
7	Firm survival: The role of incubators and business characteristics	Mas-Verdu, Ribeiro-Soriano and Roig-Tierno (2015)	Journal of Business Research	64	12.8
8	Assessing technology incubator programs in the science park: the good, the bad and the ugly	Chan and Lau (2005)	Technovation	175	11.67
9	High tech start-ups in University Science Park incubators: The relationship between the start-up's lifecycle progression and use of the incubator's resources	McAdam and McAdam, (2008)	Technovation	139	11.58
10	A bibliometric analysis of international impact of business incubators	Albort-Morant and Ribeiro-Soriano (2016)	Journal of Business Research	46	11.5
11	The Deontic justice: the role of moral Incubator principles in workplace fairness	Cropanzano et al. (2003)	Journal of Organizational Behavior	194	11.41
12	University-incubator firm knowledge flows: assessing their impact on incubator firm performance	Rothaermel and Thursby (2005a)	Research Policy	169	11.27

Table 7 (continued)

Rank	Title	Authors, year of publication	Journal	Total citation count	Average citations per year
13	Incubators: Tool for entrepreneurship?	Aernoudt (2004)	Small Business & Economics	178	11.13
14	Incubator firm failure or graduation? The role of university linkages	Rothaermel and Thursby (2005b)	Research Policy	156	10.4
15	Co-production of business assistance in business incubators—An exploratory study	Rice (2002)	Journal of Business Venturing	177	9.83
16	Assessing and managing the university technology business incubator: An integrative framework	Mian (1997)	Journal of Business Venturing	222	9.65
17	Assessing value-added contributions of university technology business incubators to tenant firms	Mian (1996)	Research Policy	230	9.58
18	The role of science parks and business incubators in converging countries: Evidence from Portugal	Ratinho, and Henriques (2010)	Technovation	94	9.4
19	The role of incubator interactions in assisting new ventures	Scillitoe and Chakrabarti (2010)	Technovation	93	9.3
20	The incubator—Positive organizational behavior: An idea whose time has truly come	Wright (2003)	Journal of Organizational Behavior	157	9.24

Source: Own elaboration based on Web of Science

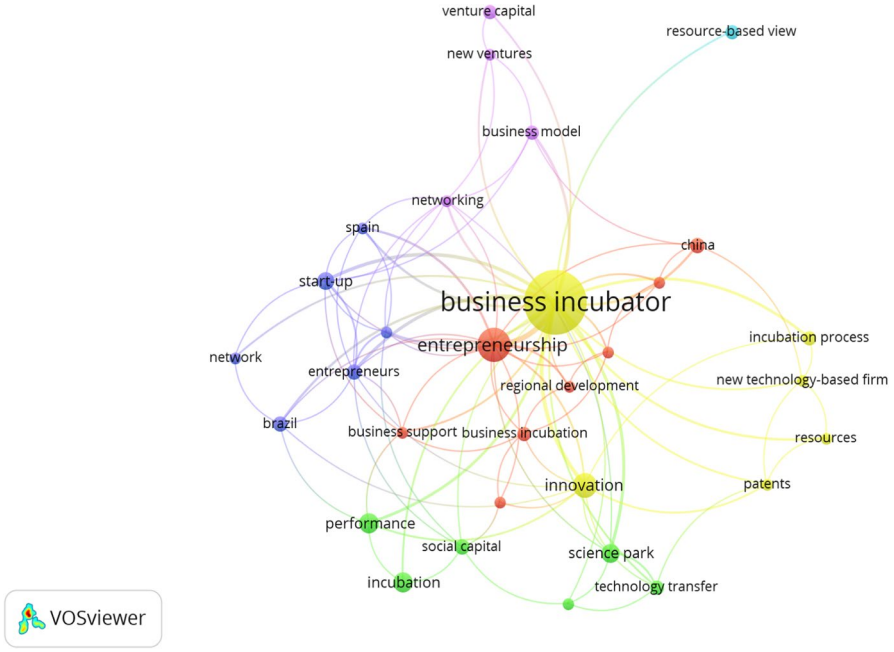

Fig. 4 Keyword Co-Occurrence Analysis. Source: Own elaboration based on VOSViewer

entrepreneur's qualities affecting the benefits of an incubation program have an impact on regional development.

2. Green Cluster: *Business Incubator Performance*: The terms "incubation" and "performance" have both the most occurrences in this cluster: eight occurrences each. An example here is Mian's (1997) study, where a new performance assessment framework is developed with the aim to evaluate the performance of university technology business incubators. Another analysis focusing on performance and incubation is from Barbero et al. (2012). The researchers evaluate company performance of four incubators by categorizing the different incubators by archetype.

3. Blue Cluster: *Business Incubator and Start-ups*: Having as many items as the previous cluster, six in total, this cluster aims the attention at the start-ups participating in a business incubator. The research of Brun (2019) presents a framework which views the start-up's development not only as an outcome of an incubation process but as well as a responsibility and result of the start-up.

4. Yellow Cluster: *Business Incubator and Innovation*: Positioned at the center of the visualization and of this study exploration, with the highest number of occurrences – 81 times, is the keyword "business incubator". The term is also connected to each cluster visualized. The second most used keyword in this cluster is "innovation" with 12 appearances. Kolympiris and Klein (2017) investigate what the influence of university-connected incubators have on university innovation. Their findings point to one of the outcomes of founding a university-related incubator is the declining quality of the innovations.

Table 8 Author Keywords Ranked by Occurrence

Rank	Keyword	Occurrences	Total Link Strength
1	Business Incubator	81	93
2	Entrepreneurship	22	33
3	Innovation	12	21
4	Performance	8	9
5	Incubation	8	4

Source: Own elaboration based on VOSViewer

Table 9 Author Keywords Ranked by Total Link Strength

Rank	Keyword	Occurrences	Total Link Strength
1	Business Incubator	81	93
2	Entrepreneurship	22	33
3	Innovation	12	21
4	Entrepreneurs	5	16
5	Start-up	6	15

Source: Own elaboration based on VOSViewer

5. Purple Cluster: *Business Incubator, Business Model, and Venture Capital*: With only four items in the cluster, two terms, "business model" and "venture capital", have the same and highest number of occurrences, four times. Both items have no connection between each other, but only to the keyword "business incubator". Therefore, the cluster does not have a one and only focus. The other two items, "networking" and "new ventures" have occurred three times. An example of the first connection is the study of Cantù (2015). In the researcher's work, the motivation of a new business model, for an incubator and based on external networking, has been explored (Cantù 2015).

6. Light Blue Cluster: *Business Incubator and Resource-Based View*: The smallest cluster, with only one item, is concerning the keyword "resource-based view", which appeared four times in the dataset being analyzed. The cluster is only connected to the term "business incubator", thus only to the yellow cluster. The research of Somsuk and Laosirihongthong (2014) is an example of this cluster. Their analysis recognises the factors having impact on university business incubators' success grounded on the resource-based view theory (Somsuk and Laosirihongthong 2014).

An overview of the five most frequently appearing author keywords (Table 8) and a comparison with the five author keywords with highest total link strength (Table 9) are shown below.

4.2.2 Bibliographic coupling analysis

Figure 5 presents the bibliographic coupling analysis of the dataset. Bibliographic coupling measures the similarity between papers by the number of shared references

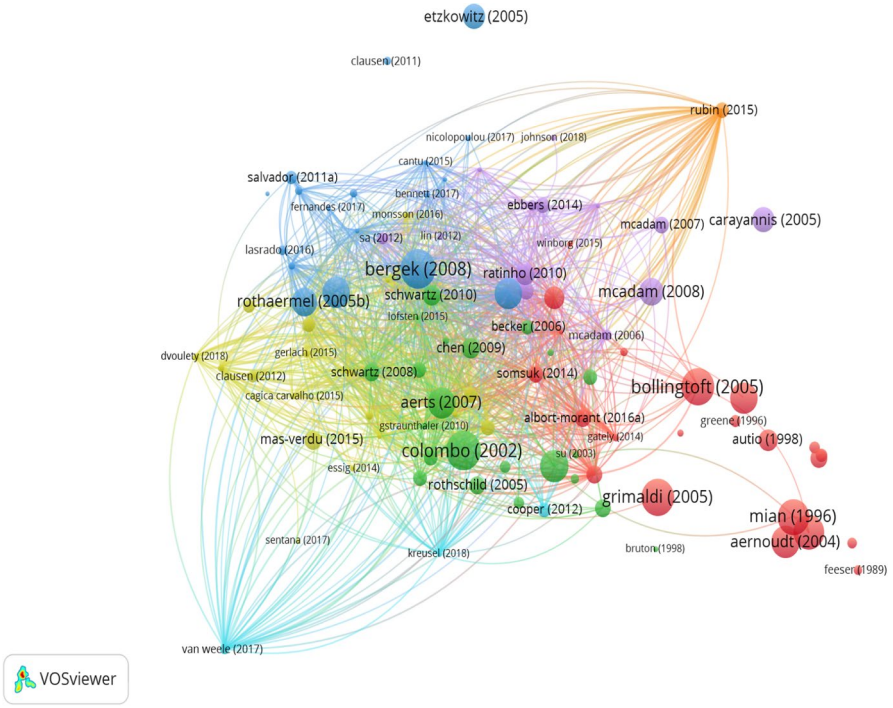

Fig. 5 Bibliographic Coupling Map. Source: Own elaboration based on VOSViewer

(Zupic and Čater, 2015). The visualization shows documents which have received a minimum number of six citations. A citation threshold ensures that only highly relevant publications are included in the analysis. It also allows for a more manageable number of publications. After applying the threshold of six citations, the dataset could be reduced to the 107 most cited publications. Six publications showed no links to other clusters so that the visualization includes a set of 101 connected publications. Each bubble in the visual represents a publication, with a bigger bubble indicating a higher number of references. The closer the bubbles are placed on the map, the more it is likely for them to reference the same document (Van Eck and Waltman 2014). Some of the items which are not close to the set in the center are not visible.

A total of seven clusters appeared and can be described as follows, focusing on highly cited papers, which best represent the respective research theme.

1. *Structure of Business Incubators:* The red cluster with 22 items identifies the structure of an incubator. Authors such as Aernoudt (2004), Bollingtoft (2012), Grimaldi and Grandi (2005), Smilor (1987b) discuss the different types of incubators. Moreover, other researchers such as Rice (2002), Scillitoe and Chakrabarti (2010), Smilor (1987b) concentrate their articles on the incubator's assistance services granted to the incubates.

2. The green cluster containing 22 items as well, is blurry, combining several topics. Still, the most researched topic in this cluster is concerned with the *tenants*

in a business incubator. Albort-Morant and Oghazi (2016) analyze different characteristics of entrepreneurs who emphasize the importance of incubators' services. Furthermore, the study of Cooper and Park (2008) examines several environmental factors which affect the tenants' behavior. Additionally, two articles (Colombo and Delmastro 2002; Lee and Osteryoung 2004) concentrate on the success of business incubators.

3. *University Business Incubators:* The dark blue cluster includes 18 items. The majority of the articles investigate university-based incubators. Rothaermel and Thursby (2005a) for instance, evaluate how knowledge is transferred from the university to the incubated company. Other researchers address the performance of university incubators. In particular, Lasrado et al. (2016) analyze whether businesses leaving incubators based in universities have more advanced post-incubation performance than businesses off incubators, whereas Wann et al. (2017) suggest eight key performance indicators for university incubation. The relationships between spin-offs and university-based incubation models (Salvador and Rolfo 2011) are researched as well. The rest of the papers are diverse. Some of them focus on innovation in incubators (Nicolopoulou et al. 2017; Clausen and Rasmussen 2011), while Bruneel et al. (2012) for instance examine different generations of business incubators.

4. *The Impact and Performance of Business Incubators:* The yellow cluster consists of 18 articles, which can be separated into two: papers focusing on the performance of the incubator and research on the impact of an incubator. An example of the first group is the analysis of Dvouletý et al. (2018) where the performance of incubated Czech companies is compared with the performance of nonincubated companies in the Czech Republic. Fonseca and Chiappetta Jabbour (2012) develop a framework in order to evaluate incubators' sustainable performance, while other researchers, such as Baerbero et al. (2012), evaluate how the different types of incubators lead to different performance. Some of the articles focusing on the impact of an incubator, such as Mas-Verdú et al. (2015) research the impact of the incubator on the survival rate of incubatees and highlight that a mixture of various factors and the incubator can guarantee the enterprises' survival. Sentana et al. (2017) examine the economic and social impact of incubators, based on research of 40 Spanish business incubators.

5. *The Network of a Business Incubator:* The purple cluster with 14 papers puts an accent on the relationships, collaborations, and connections between different parties within an incubator and outside of it. For instance, Sá and Lee (2012) give a better depiction of networks and their strategies, outlining that a variety of networks can develop in high-tech business incubators. McAdam et al. (2006) study the scientific field for processes and networks within university-based incubators in order to connect the two theories and outline scientific agendas. Another article, from Ebbers (2014), analyses two patterns of network behaviour in an incubator: individual networking orientation and tertius iungens orientation. Additionally, while distinguishing between internal and external networks, Soetanto and Jack (2013) research external connections of the enterprises and internal relationships between the entrepreneurs participating in an incubator. However, two of the articles did not share a common topic neither between each other nor with the main subject of this cluster.

6. The five items in the light blue cluster do not share a common theme. Some of the articles have no connection to business incubators. Despite that, Cooper et al. (2012) examine the communication and network within a university-based incubator. Van Weele et al. (2017) emphasize that tenants in incubators do not consider the full range of the resources provided by the incubator.

7. The last and smallest cluster, in orange, with only two items, does not have one focus, just like the previous cluster. One of the research papers does not aim at business incubators. Despite that, the research of Rubin et al. (2015) investigates the interconnections within an incubator and their effects.

5 Discussion

Incubators were first researched in a scientific study in 1987. In the period of the 32 years being analyzed, the number of publications in the first two stages, 1987–2004 and 2005–2010 remain low, making up 26% of the total number of publications. In contrast, 74% of the publications in the hole dataset were published in the last ten years. The tendency for the citations per year in the same time span is similar, where most of them are distributed in the last couple of years. Both results indicate that the scientific curiosity has grown recently, gaining its momentum. Mian et al. (2016) identified similar tendencies in the research field of business incubation. As business incubators gain relevance in terms of regional and economic development (Monsson and Jorgensen 2016), we assume, that the research interest will be growing in future and expand in the other research areas, particularly in the political and social sciences. The rise of new digital technologies and hence possibilities for virtual cooperation inside incubators might lead to the creation of new and more convenient forms of incubators that stimulate the research on this topic.

From a theoretical perspective, our research adds to the knowledge spill-over theory identified in the previous bibliometric analysis of the entrepreneurship field (Ferreira et al. 2019). In particular, we show how business incubators can be used for knowledge transfer and improve the performance of newly created firms. However, the process of knowledge spill-over in business incubators can be better understood in future research concerning the different types of incubators. Currently, there is a strong focus on university-business incubators, as our analysis shows.

A total of 99 journals, researching in different fields, published literature on incubators. This indicates a variety of directions investigating incubators. This also corresponds with the statement above, that the literature interested in this topic is multidisciplinary.

The analyses on the distribution of publications and citations per country indicate the following conclusions. Since this research was limited to documents written only in English, it is no surprise, that the two most productive countries are English-speaking. The most productive country is the US (also the country with most citation count) with 44 studies, followed by England with 19 publications. Italy makes an interesting case being third in the number of publications and second at receiving citations, whereas England is the fifth most cited country. A previous bibliometric study from Albort-Morant and Riberio-Soriano, conducted in 2016, exploring

business incubators, shows slightly different findings. While their results rank the US first as well, regarding number of publications and citations, England is the second most cited country and Italy is ninth. However, since the samples being analyzed are different in both studies, dissimilarities are possible. Interestingly, the first ten articles in the table with the most citations on average per year, belong to research conducted in Europe, while the second half is dominated by research conducted in the US. Italy has two publications in fourth and fifth place, which may explain why the country is the second most cited country in the dataset.

In terms of the analyses on productivity and citation counts of authors the following can be concluded. The most productive authors are Baskaran and McAdam, both publishing four articles, while the researcher with the highest number of citations is Mian with 529 citations. Although McAdam has more publications than Mian, his citation count puts him tenth with 243 citations. In this regard, the findings of this study align with those of Albort-Morant and Riberio-Soriano (2016) and Hausberg and Korreck (2020), where Mian obtains the highest number of citations in both research papers as well.

The last performance analysis explores the individual publications from the dataset. The articles were sorted by the average citations per year for two reasons. First, the items with most citations have the tendency to display "only the most active and prolific areas within the field" (Zhao and Strotmann 2015). Second, when ordered by the highest citation count, older publications are in favour (since they had a longer time to be cited), while newer ones are on the negative side (Zupic and Cater 2015). The study of Bergek and Norman (2008) obtains the most citations on average per year, 22.33 and 268 citations in total. However, the article of Colombo and Delmastro (2002) with most citations in total is in fourth place with 282 citations, but an average of 15.67 per year.

6 Research framework

Based on the keyword co-occurrence and the bibliographic coupling analyses, we propose a research framework (Fig. 6). In order to show the interconnections between the identified research themes, the arrows represent their connections.

A considerable amount of research has analyzed how a business incubator is structured. A simplified version of the structure of an incubator, considering some of the main elements, is presented at the left top corner of Fig. 6. The interesting path for future research offers an application of RBV to the studies of the structure of incubators. Are there some tangible or intangible resources that are particularly valuable, rare, inimitable, or exploited by the organization in a way related to performance effects? Another inquiry grounded in RBV could analyze the role of important value steams, such as physical infrastructures, formal network, or provided services, as it was recently done in research on science parks (Meseguer-Martinez et al. 2021). The tenants participating in an incubator, for instance, received a noticeable attention in the field as well (Aerts et al. 2007; Cooper & Park 2008; Schwartz & Hornych 2010). In particular, their relations with other entrepreneurs in the incubator and their connections to the managers (both in purple) presented as the internal

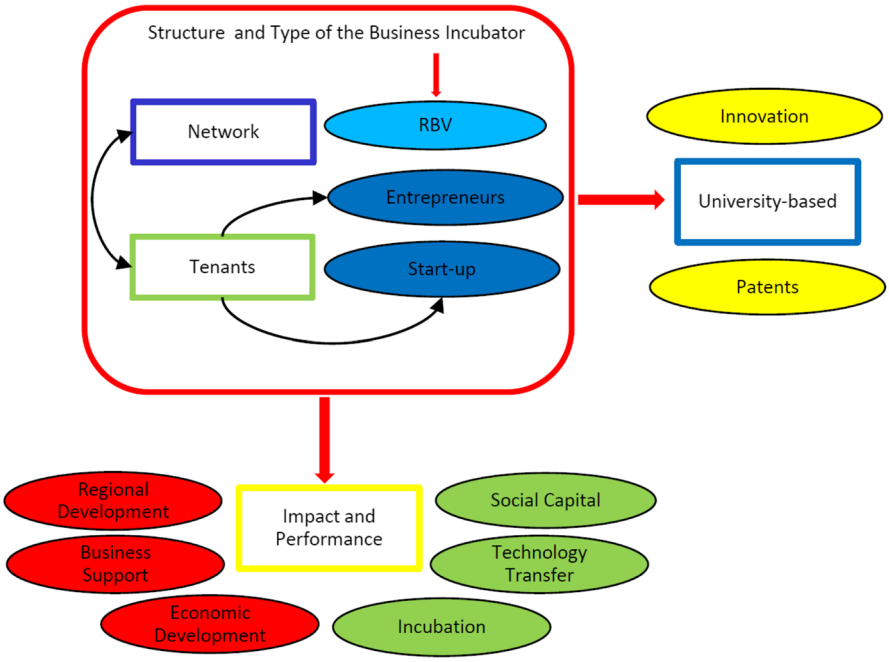

Fig. 6 Research Framework. Source: Own elaboration

network of an incubator have been reviewed. Two keywords identified in the blue cluster of co-occurrence analysis – "entrepreneurs" and "start-up" – can be applied in future studies on tenants. For example, the personality traits of entrepreneurs, such as attitudes to risk, self-identity etc. can be evaluated and discussed. In particular, the recent literature review on personality traits of entrepreneurs calls future scholars to investigate this phenomena not as a stand-alone construct, but within environmental context (Salmony and Kanbach 2021) that incubators can offer. An interesting research question would be how the incubator´s environment influences personal motivations and attitudes of entrepreneurs. An emerging path of research deals with conceptualization on how business incubators support entrepreneurial refugees (Harima et al. 2020; Meister and Mauer 2019). Research on whether and how incubators relate to entrepreneur groups, such as women/men or minorities, might bring fruitful insights to the field and important knowledge for policymakers. An interesting path for future research could be the inner network of the individual firms. With the help of questionnaires and in-depth interviews, various patterns of the relationships between the participants within the individual firms and their specific roles and responsibilities can be revealed. Additionally, there is no research on the role of business incubators in entrepreneurial ecosystems that consist of multiple actors, which is essential for achieving and sustaining growth (Bouncken and Kraus 2021).

Since "Different incubator types have different missions" (Aernoudt 2004, p. 129), the incubators based at a university (*University-based incubator*, blue) are

another type of an incubator (*Structure of the business incubator*, red) with various aims. As stated by Aernoudt (2004), different incentives and support tools for entrepreneurs started to be confused with incubators, making them an umbrella concept. This issue still seems to be problematic in current research on incubators. Thus, we need more studies on the typologies of business incubators as well as subcategories of specific types of incubators to consolidate our understanding and reduce the overlaps with other concepts. For example, by conducting cluster and regression analysis of corporate incubators from different industries, Kruft and Kock (2019) revealed five objective and strategy criteria with different impacts on incubation performance. Such kind of research can be applied to other types of incubators, with findings being useful for policymakers for planning incubation incentives for regional development. Various research has examined how the knowledge studied in the university (blue cluster) is transformed into actions and know-how for the tenants (part of the green cluster) in the business field. Another distinction in the field of incubators is the different services that individual incubators provide. Even though some of the papers mentioned above (see red cluster in the bibliographic coupling analysis) analyze the services being offered to tenants, a systematic literature review depicting the various assistance services organized by the type of an incubator is absent. Thus, entrepreneurs would be provided with information on what the different incubators have to offer. Future research on incubators can take this into consideration.

Another link between clusters can be seen between the type of incubator (red cluster) and *the performance and impact of an incubator* (yellow cluster) since some of the article mentioned above analyze the performance of individual types of incubators (Aernoudt 2004; Grimaldi and Grandi 2005). The research can extend this point in two ways. First, by using the keywords "regional development" and "economic development" from the first cluster, research can address the performance of incubators from a macro perspective, by evaluating their impact on wealth creation, local employment rates, or sustainable development. There is a growing interest from the public administration on how incubators add to the innovation and economic development (de Esteban Escobar 2020). Second, the two keywords from the second cluster – "social capital" and "technology transfer" – can be further evaluated concerning the performance effects of incubators, such as enhancement of social networks and knowledge spill-over.

Additionally, the impact a business incubator (yellow cluster) has on the success of tenants (mentioned in the green, but as well in the yellow cluster) is another visible connection. The study of Mas-Verdú et al. (2015) is one example of this. Their study focuses on how "a particular type of business incubation center" effect the success of entrepreneurs based on their firm survival rate (Mas-Verdú et al. 2015).

7 Conclusion

This bibliometric study evaluated the scientific field of business incubators in the timespan between 1987 and 2019. The performance analyses demonstrate that the research on incubators has been gaining its strength in the last ten years with the possibility to grow even further. The literature does not focus on one specific

subdiscipline, but rather connects several subfields such as management, business, engineering industrial, economics, etc. The journals in this dataset are no exception, having a multifaceted interest as well. *Technovation* published 21 articles and collected 2003 citations, which makes it the most productive and the most cited journal. The highest productivity and citation count are conducted in the United States, followed by Europe. The most prolific researchers regarding number of publications are Baskaran and McAdam, while the author with most citations is Mian, who collected 529 citations in total. When considering the average citations per year a publication receives, the top five articles are Bergek and Norrman (2008), Bruneel et al. (2012), Bollongtoft and Ulhoi (2005), Colombo and Delmastro (2002) and Grimaldi and Grandi (2005).

The science mappings confirm the multidisciplinary literature and reveal some of the topics and connections within the field further. The researchers tend to label their publications using a variety of keywords. The most common ones are business incubator, entrepreneurship, innovation, performance, and incubation. The researched streams in the field of business incubators, revealed by the bibliographic coupling analysis, focus on how an incubator is structured, the different types, in particular the university-based incubator, the tenants, the success, the network and the performance and impact of the incubator. Based on the proposed framework, multiple research opportunities occurred. The first suggests that research in the future may aim at the inner network of individual start-ups in the incubator. In addition, the second suggestion shifts the focus to the different services offered by the individual types of incubators, which could be analyzed in the future with the help of a systematic literature review. The third avenue is the usage of RBV perspective on incubators, by evaluating the most important success factors that can range from physical infrastructure to support services and knowledge. Such findings can be particularly useful for policymakers who plan or already provide incubation initiatives aiming at innovation improvement or regional development. Our fourth suggestion is to employ a behavioral perspective to analyze personal characteristics of entrepreneurs participating in incubators and to evaluate their performance. The fifth avenue we propose is to analyze the digitalization possibilities for business incubators and virtual work. In particular, there is little research on virtual incubators that could be particularly useful for international collaborations or during pandemic events.

Our research has theoretical implications. Scholars can use our findings from performance analysis as guidance to the most prominent units dealing with business incubator research. Our science mappings provide a big picture of incubator research by highlighting the most prominent topics. The emergent areas, as well as interesting avenues for future research are summarized in our research framework. The combination of different topics and identified keywords provides new perspectives that can be studied in greater detail. Entrepreneurs, managers, and politicians interested in or involved with incubators receive practical guidance of the body of research, which may be particularly overwhelming for practitioners. Practitioners are now able to find an overview of the incubator structure. Additionally, we provide practitioners with a list of possible implications incubators might have on newly created businesses. This knowledge may be useful for entrepreneurs seeking assistance, business incubator managers, or policymakers involved in regional development

initiatives. Our research framework offers a comprehensive overview of the main factors needed to be considered for the successful function of business incubators.

As with every research, our study comes with several limitations. First, the research is based on bibliographic data exported only from Web of Science. The usage of a specific database can impact the results of bibliometric analysis (Mongeon and Paul-Hus 2016). As a consequence, the results of bibliometric analyses may vary depending on the database used. Future research could compare multiple databases, and also expand the bibliometric input of the dataset. Second, the documents were restricted to only two types, thus being articles and reviews, which may have excluded other important publications. Restricting the publications only to one language may as well lead to that outcome. Researchers examining the field in the future could take this into consideration. Third, bias in the keyword co-occurrence analysis is possible since a thesaurus file was applied. Fourth, the science mapping analyses were created with VOSViewer where the data can be 'manipulated' in many ways. Thus, different outcomes may occur even when working with the same dataset.

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