

LEADING RESEARCH TRENDS ON INNOVATION FUNDING: A BIBLIOMETRIC ANALYSIS APPROACH

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Abstract

The goal of the bibliometric study is to connect key players in academic research regarding innovation funding in order to map and advance the field's knowledge. The scope is to analyze documents published on Scopus database starting from 2013 to 2022. Articles by Agrawal and Clarysse are two most cited documents. Innovation, entrepreneurship, crowdfunding, venture capital, and public funding are most co-occurrence index keywords. Journal of Innovation Policy and the Economy, Research Policy, California Management journals are leading the list of top cited documents. The analysis generated directions for future research consisting of innovation funding structure, geographic location, new investments, and shareholding horizon.

Keywords: innovation funding; bibliometric analysis; visualization networks; development trends, co-word analysis.

1. Introduction

The sustainable development of various industries and the close pressure in the domestic and foreign markets lead to the application of innovations and innovative approaches in production (Bilan et al., 2019; Strielkowski et al., 2022). The main condition for the use of scientific and technical achievements in the real sector of economic management is to engage in innovation activities (Domenech & Bahn-Walkowiak, 2019). The transition of the economy to digital market relations has made innovation activities a necessary condition for economic and ecological entities (Hao et al., 2022). For example, as a result of the use of digital

information and communication technologies in enterprises, they have changed the way they communicate and conduct relations with their customers and competitors (Le et al., 2021). Another example is after funding, geographic information systems (GIS) and remote sensing (RS) have become increasingly popular in landslide studies in Central Asia in the last decades (Khasanov et al., 2021). In the conditions of modern innovations, innovation funding on the basis of scientific-industrial cooperation is of great importance. Many foreign studies show that the financing of these innovations cannot be successful in every area, and not every type of innovation produces the same results (Powell, Walter & Snellman, Kaisa.,2004; Prokop & Stejskal, 2018). Therefore, it is often possible to observe ineffective attempts to cooperate in a number of cases of the use of national and international funds (Peri G, 2005). To ensure economic growth, it is necessary to take measures to support the creation of knowledge, to invest in appropriate infrastructure and communication technologies (Eom BY, Lee K, 2010). In addition, there is a need to develop and implement innovation funding approaches for sustainable development.

Agrawal (Agrawal et al., 2014) investigated how much economic theory, specifically transaction costs, reputation, and market design, could explain the growth of non-equity crowdfunding in the United States. Sierra (Sierra, 2019) has explored alternative frameworks for understanding how innovation is financed, taking into account the interaction of innovation characteristics, the strategic motivations of project owners and financiers, and the role of matching environments and conditions. Drawing on extensive data from national experts and the largest crowdfunding site, Mollick (Mollick & Nanda, 2016) examined funding decisions for proposed theater projects and explores the significant differences between experts and crowd preferences in this category. Caragliu (Caragliu & Del Bo, 2019) has examined the impact of Smart City policies on urban innovation in his research. At the same time, he researched the typical projects of "Smart City" involving not only large multinational corporations, but also local government bodies to attract microfunds in order to use common technological solutions for local needs. Mollick et al (Mollick & Robb, 2016) analyzed the possibilities of potentially widespread alternative infrastructures for innovation development, financing and commercialization. In her research, Aleixo (Aleixo et al., 2018) emphasized the importance of conceptual and organizational changes in higher education institutions, in particular, she studied the identification of new sources of financing and more flexible organizational forms. Hong's et al (Hong et al., 2016) goal was to study how government grants affect innovation performance in China's high-tech industry. In her study, Parhankangas (Parhankangas & Ehrlich, 2014) tested hypotheses concerning how entrepreneurs' impression innovation management strategies affect their chances of secure funding. In her research, Shadiyeva (Dildora, 2020) studied the features of financing innovative activities in the current global scenario, analyzed world leaders and trends in financing innovative activities. For his empirical research, she chose the experience of Uzbekistan in this regard. Analyzing the main sources of funds and the factors motivating the development of innovative activities, she determined the influence of some factors on the change in the volume of scientific and technical products. For example, Material, labor, and financial resources are all considered resource factors for a stable operation of the company (Abdullaev & Lazareva, 2021).

In the field of innovation funding, several statistical reviews or bibliometric studies have been conducted (Li & Xu, 2022; Ortiz-De-urbina-criado et al., 2018; Padilla-Ospina et al., 2018). All of them are focused on innovative funding methods and are implemented taking into account different databases (Strielkowski et al., 2022). Alhanakta (Al-Hanakta et al., 2021) focused on the effect of innovation in small and medium enterprises by using major indicators of bibliometric analysis to see the growth of the scientific studies in the subject matter. Ariffin (Ariffin et al., 2023) their bibliometric study aimed to map and expand respective knowledge by establishing connections between important actors in academic research regarding the government venture capitals.

The main goal of this article is a bibliometric analysis in the field of innovation funding. In this direction, we conducted a study based on several indicators and bibliometric methods using the Scopus database from 2013 to 2022. Our work in this research provides a comprehensive and in-depth picture of the state of research in the field of innovation funding. By examining bibliometric indicators obtained on Scopus, we are able to show the distribution of publications, the most prestigious journals, the most often cited works, the most significant authors, and the nations and institutions that stand out the most. Additionally, we exhibit the co-citation of authors, co-citation of journals, and co-citation of references by using VOSviewer to analyze the data.

2. Database and Methodology

Researchers who are assessing academic works in a focus field can benefit from using bibliometric analysis, a quantitative tool to retrospectively and descriptively describe published publications (Ding, 2019; Rey-Martí et al., 2016; Small, 1973). We analyzed 1278 publications on innovation funding from the Scopus database from 2013 to the end of 2022. The research techniques used in this work include statistical, comparative, bibliometric, analytical, structural, and graphical analysis based on the use of the Scopus database tools, the VOSViewer software (version v.1.6.18), MapChart, and Excel 2016 software. Our decision to use the Scopus database was predetermined by its usability and functionality. Utilizing data from the Scopus database has the additional benefit of covering more sources in the humanities and social sciences.

The VOSViewer program was used to do a bibliometric study of scientific papers published during the previous ten years in the Scopus scientometric database (using its latest available version v.1.6.18) (Van Eck & Waltman, 2007; van Eck & Waltman, 2010). The tools provided by the Scopus database to determine the leading trends in intersectoral research related to the theory of innovation funding, as well as to determine which instruments for the implementation of financial policy in the area of study garner the most interest from academics. We used VOSviewer software as a tool in this study to perform co-citation and co-occurrence analysis, and then to visualize intellectual structure.

2. Results

In this section, performance analysis results, including descriptive statistics, publication distribution, most cited publications, authors with the greatest impact, journals with the greatest

impact, institutions with the greatest influence, and most outstanding countries in platform research, are presented. The objective of this study is to gain a broad overview of development in platform research through a co-citation analysis of references, authors, and journals, as well as the related terms and clusters.

3.1 Published papers on innovation funding

The number of published papers on a particular issue shows the importance of that issue for the world. Total of 1278 papers were published for the period of 2013- 2022 in the world on innovation funding issue. Figure 2 shows that for the first 5 years 526 papers were published. From 2018 we can see the rapid increasing in the number of publications. About 41% of papers were published within the first 5 years and the rest 59% in the second 5 years. The years 2019 and 2020 were the most productive for the innovation funding issue in the world. Almost 50% of the total number of publications were published from 2018 to 2021 (Figure 1).

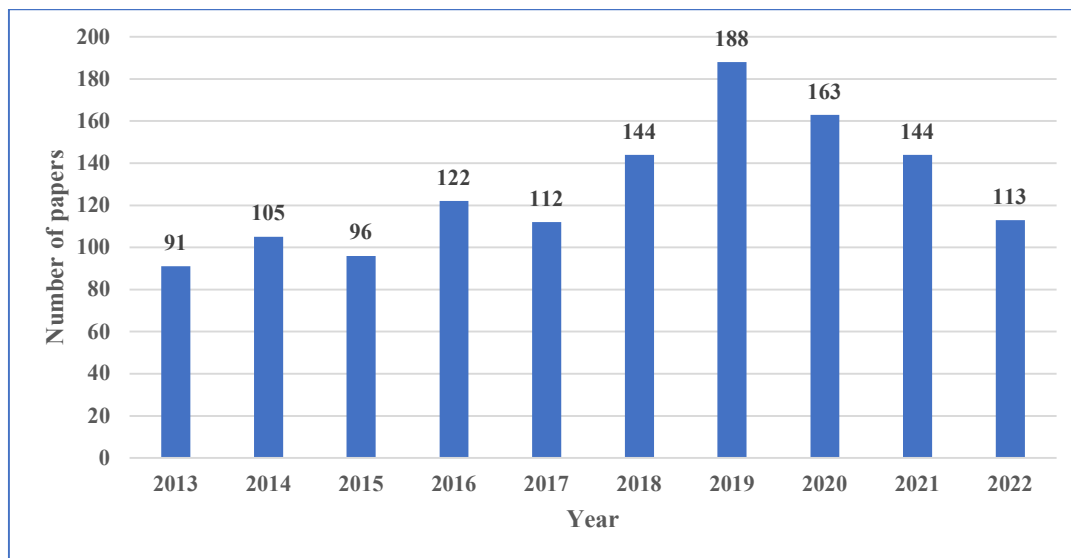


Figure 1. Number of papers on innovation funding by the year of publication.

3.2 Journals on innovation funding

Selection of the appropriate journal is essential during the publication process. Scopus based 1278 papers on innovation funding issue published in 128 different journals. About 36% from the total number of papers published in first 54 journals given in Table 1. The journals that have published more than 10 issues about innovation funding are Research Policy, Technological Forecasting and Social Change, Journal of Cleaner Production, Technology Analysis and Strategic Management, Journal of Technology Transfer, Technovation, Economics of Innovation and New Technology, Industry and Higher Education, Emerald Emerging Markets Case Studies, Technology in Society (Table 1).

Table 1. List of the journals on innovation funding in the world

Scopus Source title	Number	Scopus Source title	Number
Research Policy	48	Administrative Sciences	5
Technological Forecasting and Social Change	43	Espacios	5
Journal of Cleaner Production	25	European Journal of Innovation Management	5
Technology Analysis and Strategic Management	20	International Journal of Innovation Management	5
Journal of Technology Transfer	18	International Journal of Innovation Science	5
Technovation	15	Journal of Management Development	5
Economics of Innovation and New Technology	13	Journal of Product Innovation Management	5
Industry and Higher Education	11	Nanoethics	5
Emerald Emerging Markets Case Studies	10	Quality Access to Success	5
Technology in Society	10	Research Technology Management	5
Journal of Business Research	9	Strategic Entrepreneurship Journal	5
Journal of Commercial Biotechnology	9	Creativity and Innovation Management	4
Journal of Technology Management and Innovation	9	ENR Engineering News Record	4
Small Business Economics	9	Economy of Region	4
Academy of Strategic Management Journal	8	European Journal of Futures Research	4
Contributions to Management Science	8	Foresight	4
Journal of Responsible Innovation	8	Human Service Organizations Management Leadership and Governance	4
R and D Management	8	Innovation Management Policy and Practice	4
Evaluation and Program Planning	7	Innovation Policy and The Economy	4
Fuel Cells Bulletin	7	International Journal of Applied Business and Economic Research	4
IEEE Transactions on Engineering Management	7	Journal of Applied Economic Sciences	4

Industry and Innovation	7	Journal of Entrepreneurship Education	4
Management Science	7	Journal of High Technology Management Research	4
Innovation Technology and Knowledge Management	6	Journal of Innovation and Knowledge	4
International Journal of Innovation and Technology Management	6	Journal of Science and Technology Policy Management	4
Organization Science	6	Journal of Small Business and Enterprise Development	4
Problems and Perspectives in Management	6	Science and Innovation	4

3.3 Top countries on innovation funding

Number of countries participated in the research activities on a specific topic shows the degree of internationalization of the region. Total of 93 countries jointly worked on innovation funding issue in the world from 2013- 2022. We have selected top 15 countries participated in publishing of at least 27 and more publications in Figure 4. From the top countries United States, United Kingdom, Germany and China are leading the list by the number of publications 273, 174, 90, 80 respectively (Figure 2).

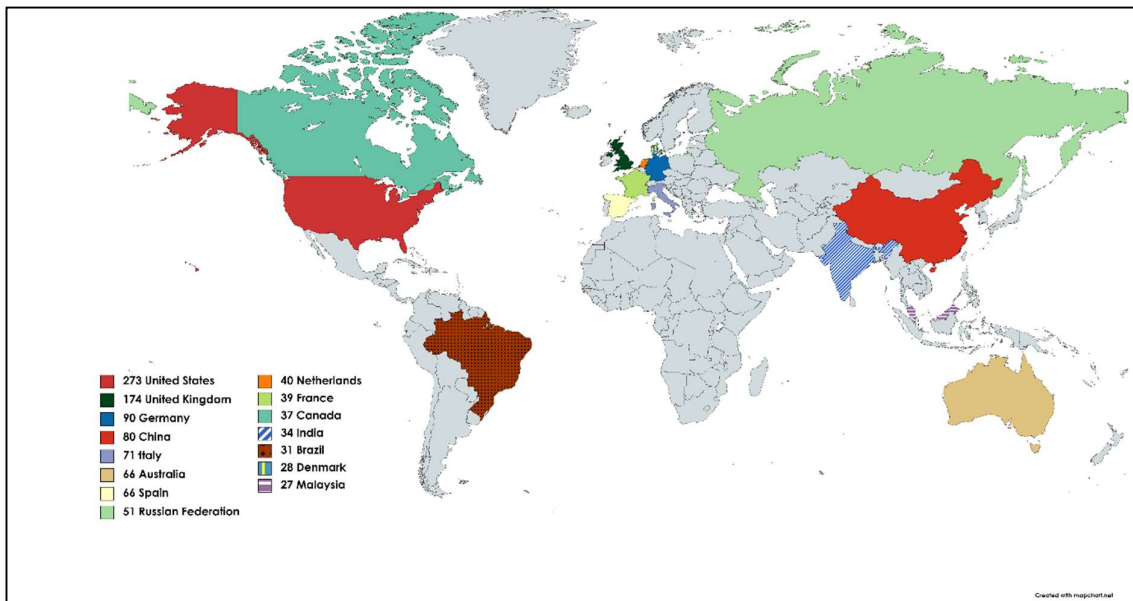


Figure 2. List of top countries on innovation funding issue.

3.4 Top institutions on innovation funding

Ranking of institutions mostly based on the quality of the papers published by the researchers of that institutions. 160 different institutions worked in cooperation to publish 1278 papers on innovation funding in the world for the period of 2013- 2022. Georgia Institute of Technology and HSE University leading the list of top institutions in Figure 44. Each of these institutions published 15 papers in the cooperation with other institutions. In Figure 4 we showed institutions where 8 and more papers were published (Figure 3).

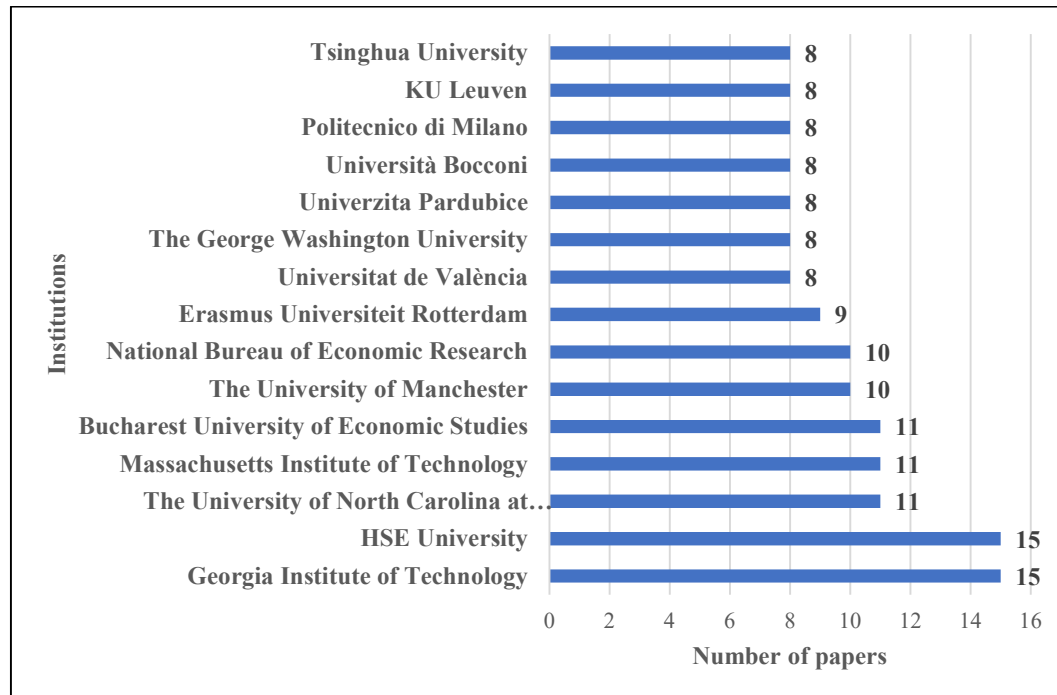


Figure 3. List of top institutions on innovation funding issue in the world

3.5 Top authors on innovation funding

Authors play an important role in a development of the particular field of research in any region. During the last decade total of 3029 different authors worked to publish 1278 papers for the innovation funding issue in the world. In the review we took the first 15 top authors who published at least 3 and more papers which is shown in Figure 3. From the list we can see that almost half of the top authors are not from Central Asian countries, but they have jointly published papers in a high ranked journal. Authors Link A.N., Stejskal J. are leading the list of top authors with a number of papers 10, 6 respectively (Figure 4) (Link, 2019; Prokop et al., 2021). Following that, Ahmad A.R., Mardones C., Prokop V., Scott J.T., Wonglimpiyarat J., each of them with a number of papers 5 (Mardones & Zapata, 2019; Prokop & Stejskal, 2019; Rahman Ahmad et al., 2020; Scott, 2019; Wonglimpiyarat, 2019). There are also Guo Y., Hong J., Park H.D., Shapira P., Soon N.K., each with four papers (Ahmad, A. R., Sunari, S. N., Soon,

N. K., Farley, A., & Ismail, R., 2016); Bordoloi et al., 2022; Gan et al., 2021; Guo et al., 2022; Kim & Park, 2017). Beaudry C., Benna I.U., wrote three papers each (Benna, 2021; Martin & Beaudry, 2015). (For citation and analysis, we used the authors' most recent articles).

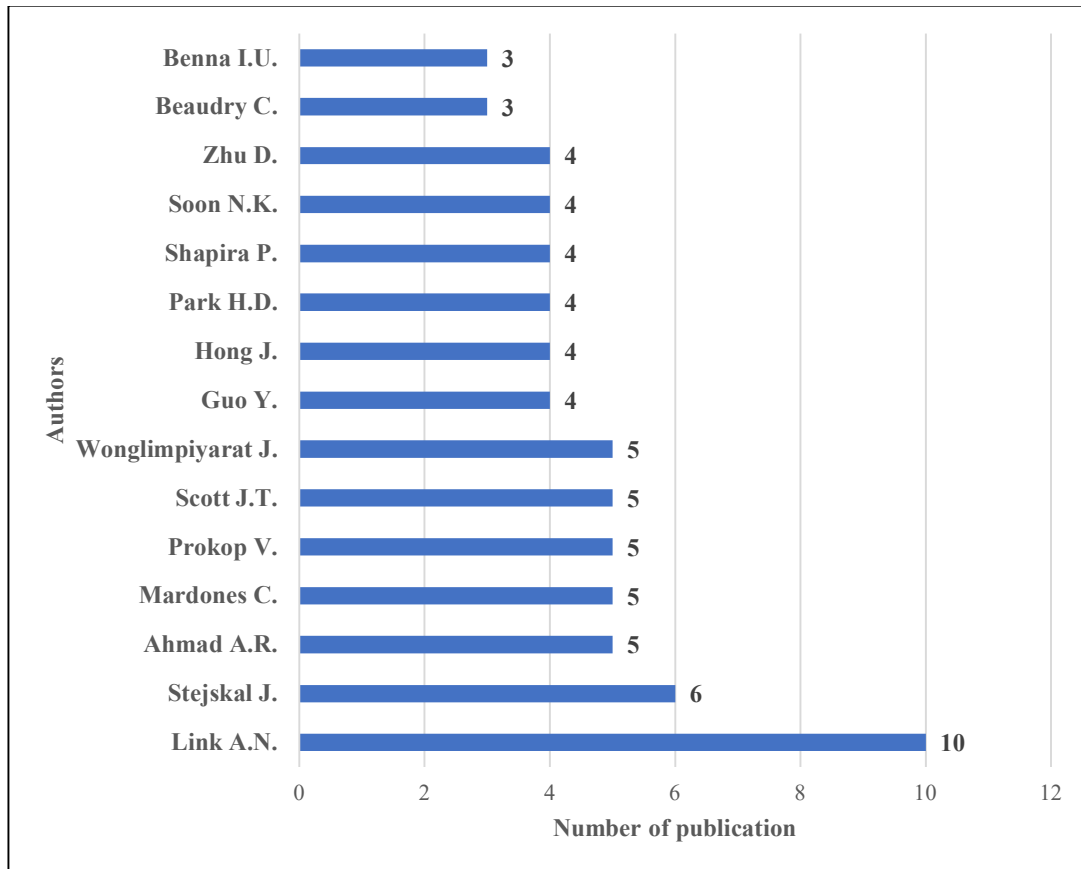


Figure 4. List of top authors published on innovation funding issue in the world

3.6 Publication type on innovation funding

There are different publication types where researchers can present their results. Figure 5 shows the different types of papers published on innovation funding issues worldwide for the given period. We obtain all types of innovation funding publications from the Scopus database. They are classified into ten types, as illustrated in Figure 5. The figure shows that the most common type of publication is articles, with 867, accounting for 67% of all documents. Following that, 175 publications are book chapters, accounting for 14%; 150 are conference papers and 35 are books, respectively. There are also 30 review materials, 10 notes, 7 short surveys, and 5 conference reviews. There are five erratums and four editorial items.

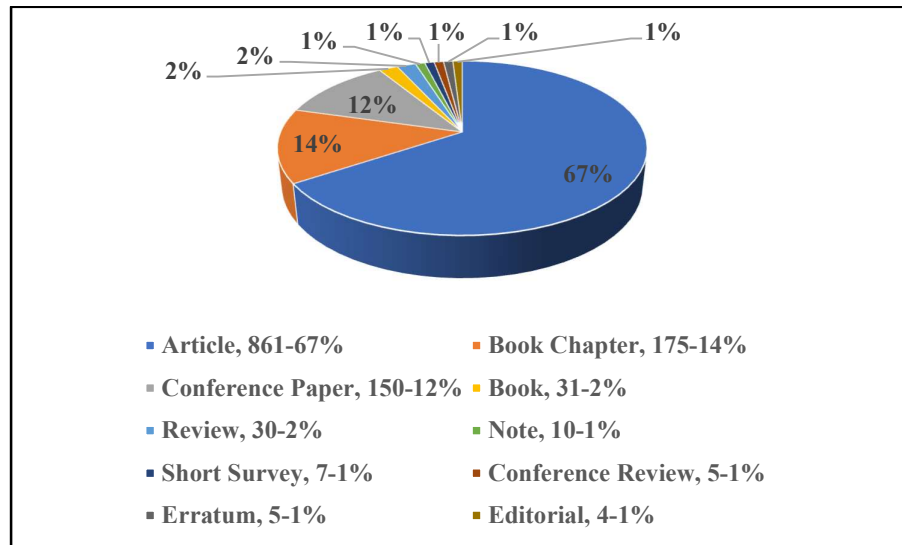


Figure 5. Publication type on innovation funding.

3.7. Top cited papers on innovation funding

Number of citations shows the quality and novelty of the conducted research. Fifteen mostly cited papers on innovation funds shown in the Figure 6. For the given period, 3029 different authors received a total of 7608 citations on global innovation funds. 12 of the top cited papers published during the first five years and the rest 3 during the second five years. Almost 44% of citations given to 15 authors from the Figure 6. First 15 top cited papers are consisting all 15 research articles. According to the citation, the first and second place are the works of Agrawal A. (Agrawal et al., 2014) and Clarysse B. (Clarysse et al., 2014). these publications with more >400 citations. the third and fourth place are the articles of Franzoni C. (Franzoni & Sauermann, 2014) and Bogers M. (Bogers et al., 2018), these publications with more >300 citations. There are another two publications with more > 200 citations (Miron-Spektor et al., 2018; Mollick & Nanda, 2016). And there are also nine publications with more > 100 citations. This explains one of the research hotspots in the field of innovation funds.

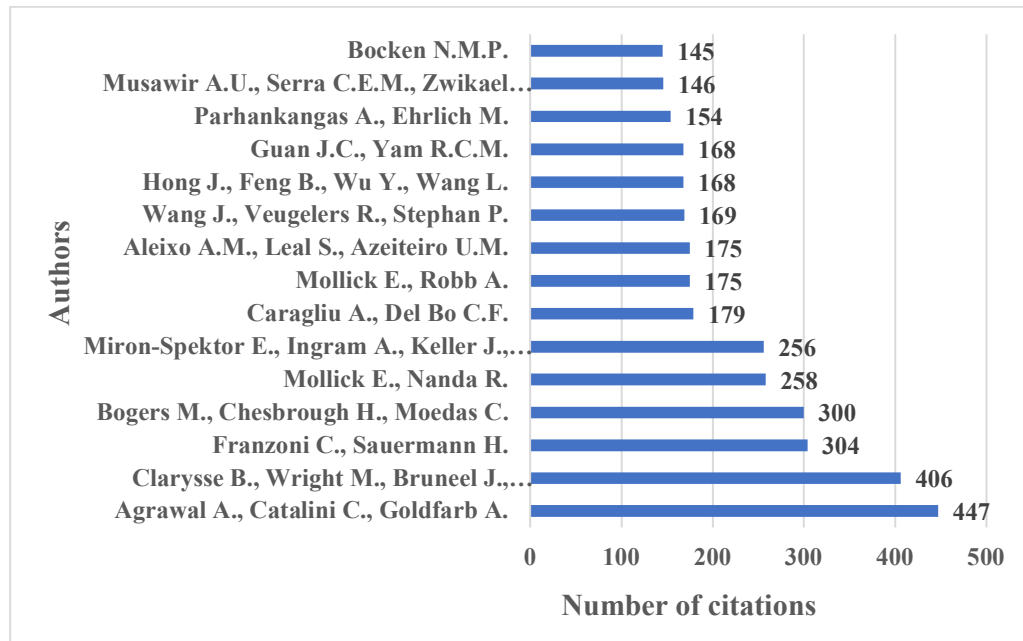


Figure 6. List of top cited authors on innovation funding.

3.8. Top cited journals on innovation funding

Total of 128 journals selected to publish 1278 papers on innovation funding in the world for the period of 2013- 2022. Top cited 15 journals selected and shown in Figure 8. Almost 14751 of total citations given to papers published in these all journals. Journal of Innovation Policy and the Economy, Research Policy, California Management journals are leading the list of top cited journals with the number of publications 447, 406, 300 respectively (Figure 7).

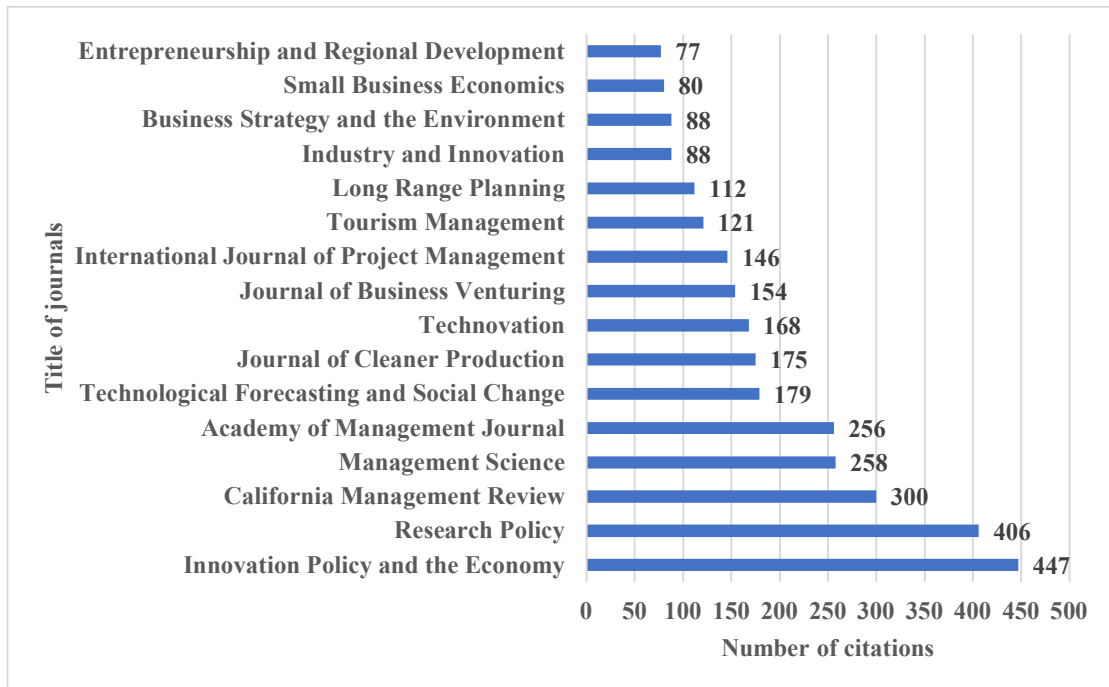
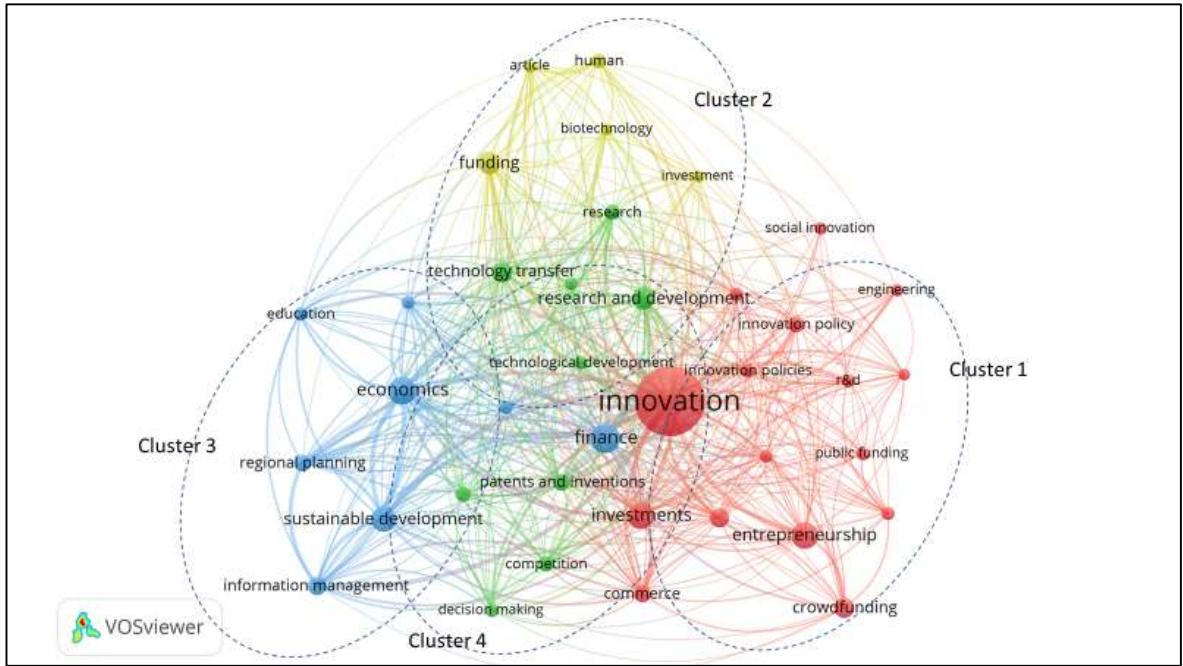


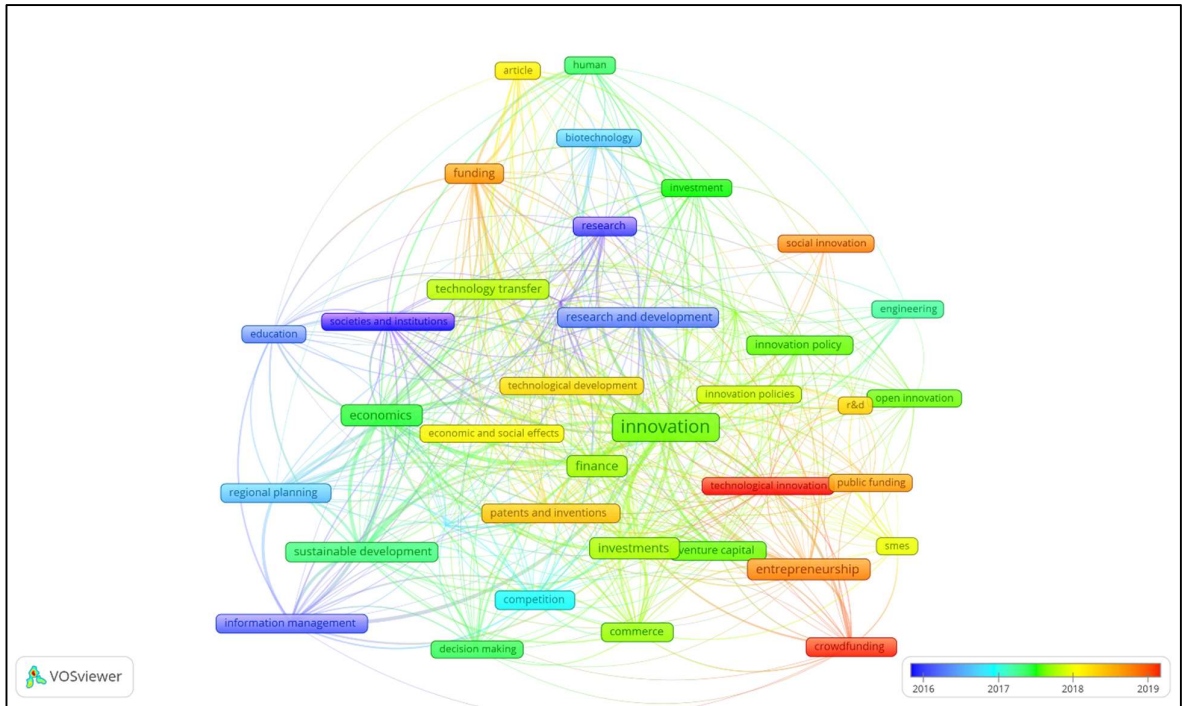
Figure 7. List of top cited journals on innovation funding in the world.

3.9. Publications by the topic cluster name on innovation funding

The bibliometric analysis reveals the dominant trends in intersectoral research related to each group of these tools. According to the results of bibliometric analysis of the frequency of using the key phrases “innovation funding” in scientific papers, a sample of 1278 articles was formed, 5379 keywords were identified (the frequency is a multiple of 20 or more). Innovation funding is most often studied simultaneously with research in the following areas to stimulate innovative development: 1) innovation, finance and investments; 2) research and development, technology transfer, patents and inventions; 3) finance, economics and sustainable development; 4) human funding, biotechnology and investment (clusters 1–4 in Fig. 8 and table 2).



a)



b)

Figure 8. The dominant clusters of connected with keyword "innovation funding" in scientific papers (N = 5379 items).

Table 2. Clusters resulting from the most-used keywords

keyword	occurrences	total link strength	keyword	occurrences	total link strength
CLUSTER 1			CLUSTER 2 (continue)		
innovation	371	688	competition	32	87
entrepreneurship	75	119	research	31	100
investments	74	234	engineering research	30	73
crowdfunding	48	69	technological development	25	62
venture capital	43	103	decision making	23	69
innovation policy	34	69	industry	22	62
commerce	36	128	CLUSTER 3		
innovation policies	26	79	finance	88	249
public policy	25	75	economics	83	293
public funding	24	37	sustainable development	68	219
r&d	24	52	regional planning	36	165
technological innovation	22	56	information management	42	191
engineering	21	31	economic and social effects	25	75
social innovation	21	15	education	25	88
open innovation	20	39	societies and institutions	24	92

CLUSTER 2			CLUSTER 4		
research and development	59	177	human	28	89
technology transfer	50	121	funding	59	169
patents and inventions	37	103	biotechnology	20	70

Source: Own results based on VOSViewer v.1.6.18 software.

Discussion and Conclusions

We consider some current issues and potential future research directions based on the analysis of innovation financing. From the annual publications and trends, we can see a significant increase in the number of documents until 2019. We can see a significant increase in the number of documents until 2019 based on annual publications and trends. The keywords like innovation, entrepreneurship, investments, crowdfunding, and venture capital frequency rank at the top when combined with the popular keywords in Table 2. It seems sense that re-conceptualization processes have drawn a lot of attention because they were impacted by the 2008 financial crisis (Li & Xu, 2022). Accordingly, the new research fields called crowdfunding, venture capital, public funding (they rank in the top 30 most frequent keywords, meanwhile, it is a hot topics in the cluster 1 of the timeline view in Figure 8b and table 2) have developed innovative funding products and services. The funding of technological and social innovations has received a significant amount of attention over the past five years and is expected to receive more attention in the future. In summary, innovation funding challenges are mainly related to technological innovation, technology transfer, regional planning, biotechnology, and digital economy. According to the analysis results and the challenges outlined above, the following possible research directions can be identified:

- ✓ improve the entrepreneurial funding's adaptability and effectiveness;
- ✓ spend wisely and make the innovation policy stronger;
- ✓ incorporate findings from several sectors and disciplines to advance engineering research;
- ✓ specifically, simplify the decision-making process under the increasing innovation funding.

In this way, innovative financing can help enterprises keep up with current trends. All stages of innovation funding processes require specific methods of labor organization, management, and staffing. But in order to succeed in the market, it is necessary to bring different departments of the organization into a whole chain.

Overall, the analytical summarize conducted in this paper on the basis of VOSviewer tools allowed us to analyze key concepts related to innovation funding in the world over the last decade. There are 127 papers published on average every year. It has been determined that 2019 marked the greatest year for the distribution of publications.

This study compiles all the articles discovered on the academic Scopus website, evaluates the present foundation features of the papers, and discusses the benefits and

established technology of bibliometrics. A joint analysis of innovation funding and entrepreneurship topics is possible using bibliometric techniques. The bibliometric analysis of innovation funding has been used in several studies.

Thus, anti-centralization of the investment process (privatization of the state sector, development of the private capital sector, emergence of venture firms with different forms of ownership) in line with economic changes creates different forms of financing innovation projects. In this regard, it is of great importance to ensure the introduction of a clear strategy of structural changes, its orientation to productive competitive production, as well as the ability to use the wide possibilities of direct and indirect management of the flow of private and public capital to finance innovation activities.

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