
Top 100 Highest Cited Papers in Scientometric From 2013 to 2022: a Bibliometric Analysis

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ABSTRACT: *The present study deals with the bibliometric analysis of the top 100 highest-cited Scientometric papers from the Web of Science (WoS) database during the year 2013 to 2022. The software Bibliometrix and VOSviewer were used for the analysis of the data. We retrieved 885 manuscripts by using the search term “Scientometric analysis” and its synonyms then sorted them in “Highest Cited First” order in the WoS database. After that, 100 manuscripts were taken as per their citation count for the study. The result reveals that the Year 2020 was the most productive (20 papers) year. The word “Impact” was the most frequent word as it occurred 18 times during the period. Among 377 authors, Thelwal M was the most prolific author as he contributed 5 papers and China was the most productive country as it shares 28% of the total papers. LEIDEN UNIVERSITY holds the maximum number of papers, i.e., 44.*

Keywords: Scientometric Analysis, Bibliometrics, WoS, Citations, Scientific Production

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1. Introduction

One of the most remarkable contributions of Eugene Garfield was the *Science Citation Index* (SCI). Very soon, it was recognized as a novel instrument in the empirical study of the sciences (de Solla Price, 1965; Cole and Cole, 1973). Scientometrics can be defined as the “quantitative study of science, communication in science, and science policy” (Hess, 1997, p. 75). The exponential growth of scientific literature as stated by Fortunato et al. (2018) “early studies discovered an exponential growth in the volume of scientific literature ... a trend that continues with an average doubling period of 15 years” has put the challenge before the scientific community to find and analyse best research in their field, in this context Scientometrics plays a powerful instrument that quantitatively and qualitatively analyses any scientific literature. The present study pertains to bibliometrics analysis of the 100 highest papers in the field of Scientometrics from the WoS database. This study will help the researcher in locating the best research in the field of Scientometrics during the last decade.

2. Literature review

Lokhande (2013) in his study analysed the Nanotechnology literature published during the period 2006–2010 by using the Scopus database. The study reveals that the USA was the most productive country. It was also found that except 2009 literature growth increased every year. The proceedings of SPIE, the International Society for Optical Engineering, were identified as the most favoured source title. Singh (2016) conducted an extensive study that provided insights into the research output at Banaras Hindu University. The research encompassed a multifaceted analysis utilizing data sourced from Scopus, one of the world’s largest and most widely used abstract and citation databases. The results underscored a gradual increase

in research publication growth rates at Banaras Hindu University, particularly in subjects related to Pharmacology, Toxicology, Pharmaceutics, and Chemistry. The majority of publications were obtained from reputable journals such as Current Science and RSC Advances. Merigó & Yang (2017) conducted a study to identify significant research contributions in the domain of operations research and management. This investigation involved an analysis of the Web of Science database. The present study provided significant contributions by offering unique insights, which encompassed the categorization of various subjects and an in-depth examination of the journals that exerted the most influence. The study underscored the significant presence of the American school within the domain of operations research and management. The United States exhibits a leadership position in prominent academic journals such as Management Science and Operations Research, as well as boasts renowned scholars like Cooper and Charnes. The study undertaken by Pathak et al. (2017) provides a bibliometric analysis of the research publication output of academic members at Guahati University over a period of 30 years (1989-2018). The objective of the study was to evaluate the distribution of publication output, growth rates, compound annual growth rate, relative growth rate, and doubling time of articles across several years. The study also examined the pattern of authorship, productivity of authors, and levels of collaboration in articles. Hodonu-Wusu & Lazarus (2018) conducted a bibliometric analysis that offers a comprehensive review of research conducted in the subject of Library and Information Science (LIS) from 1980 to 2017. The research conducted in this study involved an analysis of multiple characteristics that have an impact on the effectiveness of research. These elements include the number of authors involved in a study, the institutions they are affiliated with, the sorts of documents produced, and the keywords used. The study also explored the relationship between these factors and the number of citations received by the research. This analysis encompassed contributions from various nations, differences observed across different publication years, and the identification of active research fields and primary journal outlets. Jin et al. (2020) conducted a thorough review of the 100 most commonly cited research publications on the subject of liver cancer in their scholarly publication. The primary source of data for this study was the Web of Science (WoS) database. In the sample of 235,687 papers obtained, the researchers made observations regarding the citation count (TC) of the top 100 highly cited papers in the field of liver cancer, which varied between 612 and 5358. A total of 100 scholarly articles were allocated across 31 unique academic journals, with contributions originating from nine various nations. The University of Barcelona has emerged as the primary contributor, exhibiting the highest publication output and achieving the most substantial TC. Shao et al. (2021) in their study conducted a bibliometric analysis of scholarly literature pertaining to Green Infrastructure, utilizing a Web of Science database including the time period from 1990 to 2020. A noticeable increase in scholarly output has been observed in the field of literature starting from 2014. The United States has emerged as the leading country in terms of paper publication, with China and England following closely behind in the rankings. D. Hasse demonstrated exceptional productivity as an author, having authored a total of 29 papers. The analysis reveals a substantial increase in gastrointestinal literature between the years 1990 and 2020.

3. Objectives

The goal of this study is to perform the bibliometric analysis of the top 100 highest cited papers in the field of Scientometrics from 2013 to 2022 using the WoS database. The following are some other objectives-

- To find out year year-wise distribution of publication
- To find out the most prolific author and author's productivity over time
- To find out the most productive country, country-wise distribution and, highly cited country
- To find out the average citation per year
- To find out the annual scientific production
- To find out the most relevant affiliation
- To find out frequently used keywords

4. Methodology

The present study adopted the following four steps methods:

Step 1: Database Selection

For the present study, the Web of Science Database was searched on October 18, 2023, with the following search strategy:

Step 2: Search strategy

- **Search type-** Advanced search
- **Search operator-** OR

- **Search terms** (Using “OR” Operator)- “Scientometrics analysis” OR “Science indicators” OR “Science measurement” OR “Research evaluation” OR “Research analytics” OR “Research metrics” OR “Research performance” OR “Research impact” OR “Scholarly metrics”
- **Field type**- Title only
- **Custom date range**- 01-01-2013 to 31-12-2022 in DD-MM-YYYY format

By applying the above-advanced search strategy, we retrieved 885 research papers.

Step 3: Sorting of retrieved articles within a database

The retrieved 885 articles were sorted by “Highest citation first” order within the database and the first 200 articles were checked for whether they were related to the field of scientometrics or not. In this process, 100 articles were found suitable and they were downloaded in plain text file format. Out of which 68 were articles, 1 was a proceedings paper, 2 were editorial material and 29 were review articles.

Step 4: Selection of Bibliometric Tool

The dataset obtained from the Web of Science was later imported into “Bibliometrix,” a specialised R statistical programming language tool designed for doing quantitative research in the fields of Scientometrics and Bibliometrics.

5. Data analysis

5.1. General Information

The current investigation focuses on an analysis of the top 100 highly cited research articles in Scientometrics published from 2013 to 2022, as listed in the Web of Science (WoS) database. These articles were sourced from 56 distinct journals. Within this set of highly cited papers, 68 were categorised as original articles, 29 were identified as review papers, one was classified as a conference proceedings article and 2 as editorial material. The average citation count per document was determined to be 61.07. The study involved a total of 377 authors, with five of the documents being authored by a single author. On average, there were 4.05 co-authors per document.

5.2. Annual Scientific Production

The figure 1 shows the trend of papers published in Scientometrics from the year 2013 to 2022. It is clearly seen that overall there is an increase in the papers over the period of time. Year 2020 has witnessed the highest number of papers followed by the years 2019 and 2013. Scatter chart analysis reveals a clear upward trend ($R^2=0.105$) when a trend line or Line of Best Fit is established through the data.

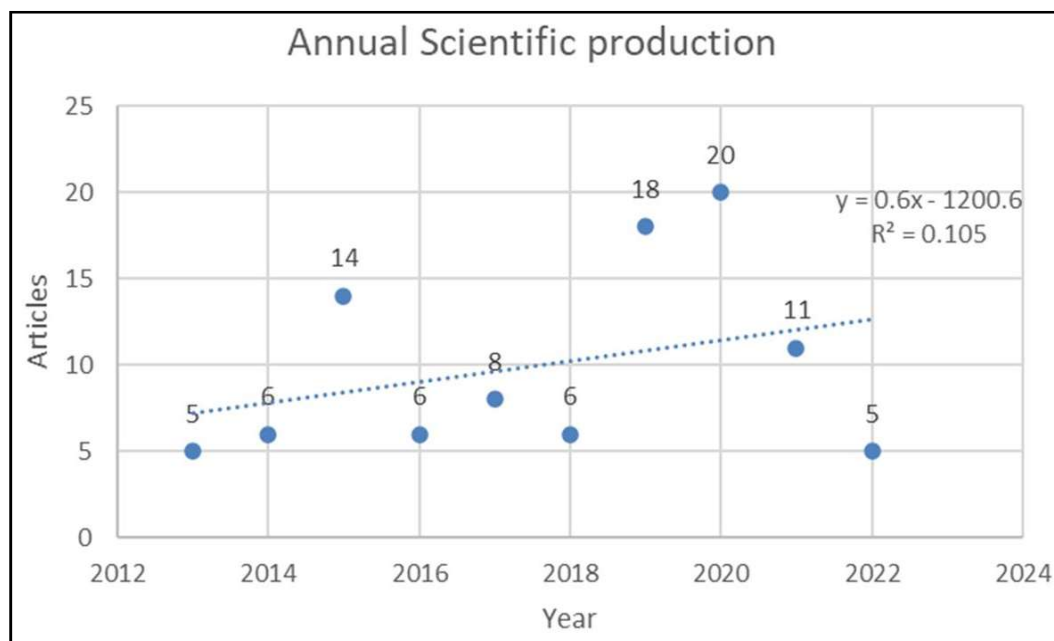


Figure 1. Annual Scientific Production

5.3. Average Citation Per year

The figure 2 shown below provides a comprehensive summary of the average Total Citations (TC) per year throughout different years. It is worth mentioning that the year 2022 had the greatest average total citations per article, with a value of 18.7, whereas the lowest average was observed in 2013, i.e., 4.49. Furthermore, it is worth noting that the second-highest average total citations per article was seen in the year 2021, with a value of 16.64, and this was followed by a mean of 13.89 in 2018. It is worth noting that the coefficient of determination (R^2) indicates a growth rate for the mean total citations (TC) per year ($R^2 = 0.7625$).

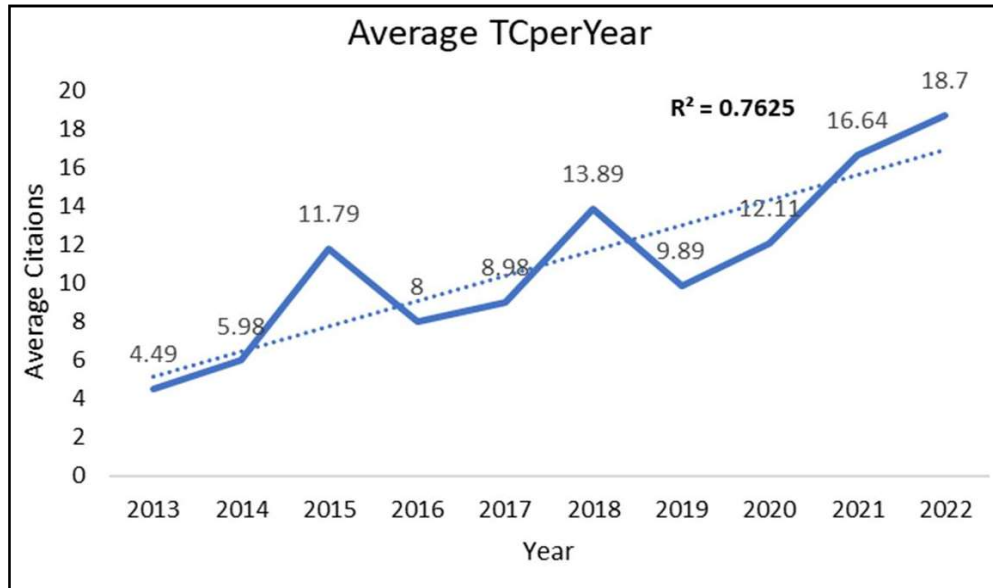


Figure 2. Average Citation per year

5.4. Most Relevant Author

Figure 3 shows the top 10 most prolific authors based on contributions made by them. Thelwal M is the top contributor by contributing 5 number of articles and obtained the 1st rank followed by Kousha A who contributed 3 articles and obtained 2nd rank. Ahmad A, Ahmad W, Bornmann L, Chan APC, Costas R, Darko A, Goerland F, Hosseini MR have contributed 2 articles.

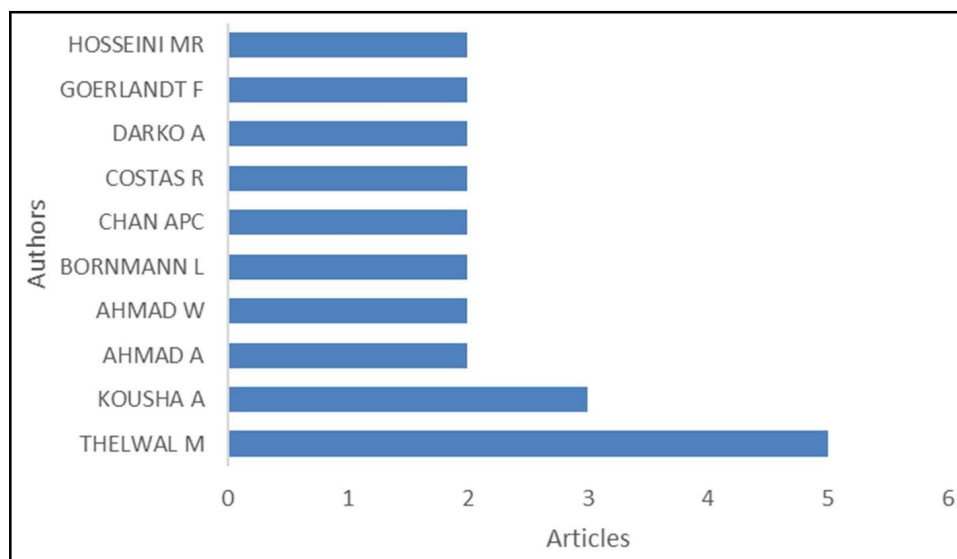


Figure 3: Most Relevant Authors

5.5. Authors' Productivity Over time

Table 1. Authors' Productivity over Time

Author	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
AHMAD A										2	2
AHMAD W										2	2
BORNMANN L	1	1									2
CHAN APC							1	1			2
COSTAS R		1		1							2
DARKO A							1	1			2
GOERLANDT F								2			2
HOSSEINI MR						1		1			2
KOUSHA K			3								3
THELWAL M			5								5

Table 1 shows the top 10 authors during the period of 2013 to 2022 in terms of paper contribution. In this regard, Thelwal, M is the most productive author producing 5 papers. The second most productive author is Kousha, K who has contributed 3 articles over the period 2013-2022.

5.6. Authors' Productivity using Lotka Law

Table 2. Authors' Productivity using Lotka Law

Documents written	N. of Authors	Proportion of Authors
1	353	0.936
2	22	0.058
3	1	0.003
5	1	0.003

By applying Lotka Law the Table 2 shows that out of 377 authors, there are 353 authors who authored 1 paper, 2 papers have been authored by 22 authors. A single author has contributed three articles while another has contributed five articles.

5.7. Most Relevant Affiliation

Table 4 depicts about authors affiliated with the most productive institute. In this context Leiden University, have produced 5 or more articles each year since 2016. Authors from the University of Wolverhampton have interestingly authored 5 articles each year since 2015. Leiden University - Excl LUMC affiliated authors have produced 3 articles each year from 2015 to 2020 and 5 articles each year in the next 2 years. Authors affiliated with CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS (CSIC), the fourth position holder, have consistently authored 3 articles each year since 2015. Authors from the National University of Singapore are seen to have been active from 2019; in the first two years, they produced 4 articles each year and in the next two years, they authored 5 articles each year.

It has also been observed that the top 4 countries in the list of 10 leading countries belong to Europe, the next two are from Southeast Asia, the next two are from Canada and Belgium, and the last two belong to China.

The top two universities, Leiden University and the University of Wolverhampton, have produced 44 and 40 articles, respectively, but the article production from other successive institutes is comparatively very low. We can clearly see that there is an increase in the number of institutions with a decrease in the production of articles, i.e., there are a few institutions that are producing multiple articles, and most of the articles are produced by authors affiliated with a few institutions.

Table 4. Most Relevant Affiliation

Affiliation	Articles
LEIDEN UNIVERSITY	44
UNIVERSITY OF WOLVERHAMPTON	40
LEIDEN UNIVERSITY - EXCL LUMC	28
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS (CSIC)	25
NATIONAL UNIVERSITY OF SINGAPORE	18
NGUYEN TAT THANH UNIVERSITY (NTTU)	16
UNIVERSITY OF TORONTO	16
KU LEUVEN	16
TONGJI UNIVERSITY	12
CHINESE ACADEMY OF SCIENCES	11
SOUTHWEST UNIVERSITY OF SCIENCE AND TECHNOLOGY - CHINA	11
HONG KONG POLYTECHNIC UNIVERSITY	11

5.8. Country-wise Scientific Production

Table 5 clearly depicts that China is the leader in terms of paper publication, contributing 332 articles. The second-ranked country, Italy has generated a total of 135 articles. The United Kingdom made a significant contribution of 119 papers, resulting in achieving the third position. The United States of America contributed a total of 112 articles and achieved the fourth position in the ranking. Netherland has secured 5th position by contributing 109 articles and Spain has made contributions of 102 articles and attained 6th place. Similarly, Australia, Malaysia, India and Portugal have contributed 98, 54, 52 and 44 articles thereby obtaining 7th, 8th, 9th and 10th positions respectively.

Table 5. Country-wise Scientific Production

Country	Articles	Share	Rank
CHINA	332	28%	1
ITALY	135	11%	2
UNITED KINGDOM	119	10%	3
USA	112	9%	4
NETHERLAND	109	9%	5

SPAIN	102	9%	6
AUSTRALIA	98	8%	7
MALAYSIA	54	5%	8
INDIA	52	4%	9
PORTUGAL	44	4%	10
Total	1157		

5.9. Most highly Cited Countries

Table 6 depicts that China is the leader in terms of Total citations i.e., 1692 and secured 1st rank followed by USA (TC=1028) and AUSTRALIA (TC=426) while Lithuania (292) obtained 1st rank in terms of average article(314) citation followed by USA (171.3) and Malaysia (128).

Table 6. Most Highly Cited Countries

Country	TC	Rank	Average Article Citations	Rank
CHINA	1692	1	58.3	4
USA	1028	2	171.3	2
AUSTRALIA	426	3	53.2	7
UNITED KINGDOM	351	4	43.9	8
NETHERLANDS	328	5	54.7	5
LITHUANIA	314	6	314	1
MALAYSIA	256	7	128	3
ITALY	181	8	36.2	10
BELGIUM	161	9	53.7	6
SPAIN	153	10	38.2	9

5.10. Top 10 most Global Cited Papers

Table 7 shows top 10 global cited papers with their total citation count and total citation per year arranged by the “largest to smallest” of Total TC. In this respect paper entitled “Bibliometrie: Das Leidener Manifest zu Forschungsmetriken” with the first author “Hicks, Diana” got the first rank with the Total TC 814 followed by papers entitled “Critical evaluation of off-site construction research: A Scientometric analysis” and “Artificial intelligence in the AEC industry: Scientometric analysis and visualization of research activities” with the total TC 314 and 201 respectively.

5.11. Most Frequent Words

Figure 4 depicts that the word “Impact” is the most frequent as it occurred 18 times followed by the word “Science” and “Management” that occurred 16 and 12 times respectively. Apart from these words “bibliometric analysis”, “trends” are used 11 and 8 times respectively. Keywords “Index”, “patterns” and “performance” are used 7 times and “innovation”, life-cycle assessment are used 6 times.

Table 7. Top 10 Most Global Cited Papers

Title	Year	First author	Total TC	TC per year	Rank
Bibliometrie: Das Leidener Manifest zuForschungsmetriken	2015	Hicks, Diana	814	90.44	1
Critical evaluation of off-site construction research: A Scientometric analysis	2018	Hosseini, M. Reza	314	52.33	2
Artificial intelligence in the AEC industry: Scientometric analysis and visualization of research activities	2020	Darko, Amos	201	50.25	3
Mapping the managerial areas of Building Information Modeling (BIM) using scientometric analysis	2017	He, Qinghua	197	28.14	4
A scientometric analysis and visualization of global green building research	2019	Darko, Amos	157	31.4	5
The scientific literature on Coronaviruses, COVID-19 and its associated safety-related research dimensions: A scientometric analysis and scoping review	2020	Haghani, Milad	146	36.5	6
A review on ionic liquids as sustainable lubricants in manufacturing and engineering: Recent research, performance, and applications	2017	Amiril, SA Sani	146	20.86	7
Assessment of research fields in Scopus and Web of Science in the view of national research evaluation in Slovenia	2014	Bartol, Tomaz	114	11.4	8
A scientometric analysis and critical review of construction related ontology research	2019	Zhong, Botao	112	22.4	9
A review of biolubricants in drilling fluids: Recent research, performance, and applications	2015	Kania, Dina	110	12.22	10

5.12. Words' frequency Over time

It is clear from the below Table 8 that "Impact" is the most frequent word over the period of time i.e., it occurred 103 times from 2013 to 2022. The second most frequent word is "Science" as it has occurred 64 times in the same period of time. The third most frequent word from 2013 to 2022 is "Bibliometric analysis" as it occurred 49 times.

Table 8. Words' Frequency over Time

Year	IMPACT	SCIENCE	MANAGE MENT	BIBLIO METRIC ANALYSIS	TRENDS	INDEX	PATTERNS	PERFORM ANCE	INNOV ATION	LIFE- CYCLE ASSESS MENT
2013	4	1	0	2	1	1	2	0	1	0
2014	5	2	1	2	1	1	2	0	1	0
2015	8	3	1	3	2	3	2	0	3	0

2016	11	4	1	5	2	4	3	0	3	0
2017	12	5	2	5	4	5	5	1	4	0
2018	13	8	3	5	4	5	6	2	5	0
2019	15	11	8	7	7	5	6	2	5	4
2020	17	14	11	10	8	7	7	4	5	4
2021	18	16	12	10	8	7	7	7	6	5
2022	18	16	12	10	8	7	7	7	6	6
Total	103	64	39	49	37	38	40	16	33	13

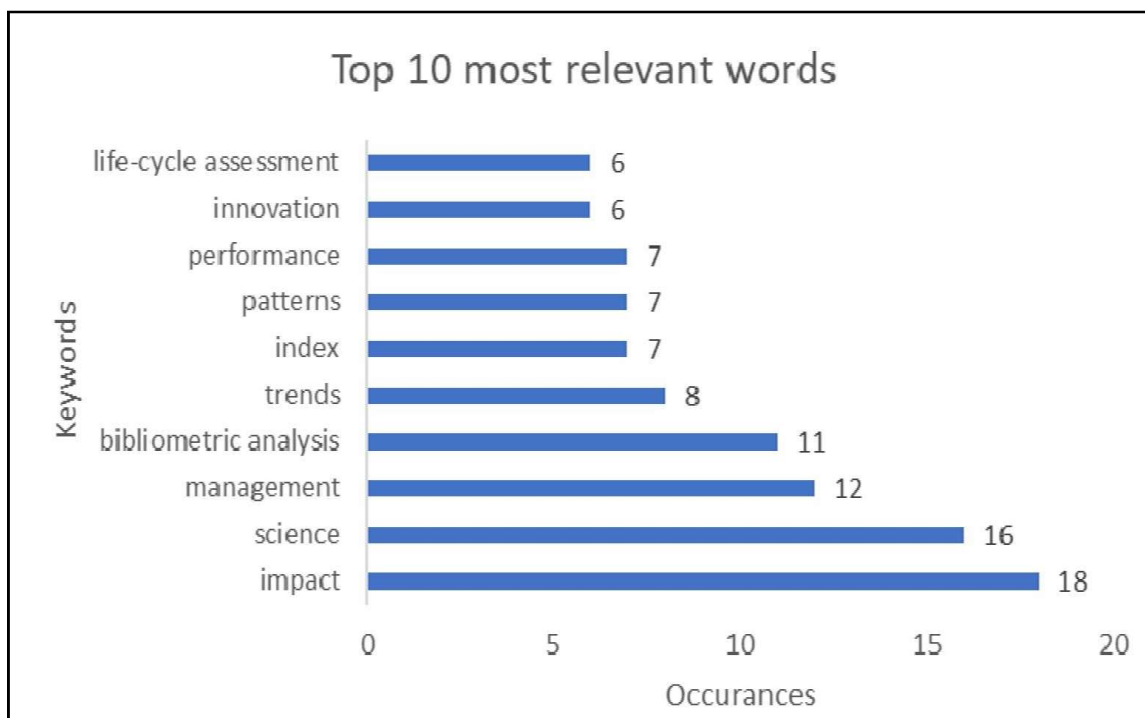


Figure 4. Top 10 Most Relevant Words

5.13. Co-occurrence Network of the Most Frequently used Keywords

The keywords of top 100 cited papers are divided into four clusters. Clustering within VOSviewer is founded upon the principle of minimising inter-keyword distances, thereby facilitating the aggregation of closely associated keywords into cohesive clusters. Subsequently, the quartet of keywords exhibiting the closest proximity within each of these clusters are as follows: 1. Altmetrics, bibliometrics, citation analysis, citations, google scholar, impact, index, publications, research evaluation, science and scopus (n=11); 2. Bibliometrics analysis, citespace, construction, emerging trends, life-cycle assessment, literature review, model, scientometric, scientometric analysis, sustainability and vosviewer (n=11); 3. management, performance, research, scientometrics and trends (n=5); 4. Collaboration, innovation, patterns and research performance (n=4).

The top two keywords – scientometrics and citespace – have most of the occurrences and also have strong link strength between them. It can be understood that CiteSpace – a freely available Java-based software tool developed for the purpose of visualising and analysing developing trends and identifiable patterns within the domain of scientific publications – is the most used software for scientometric analysis.

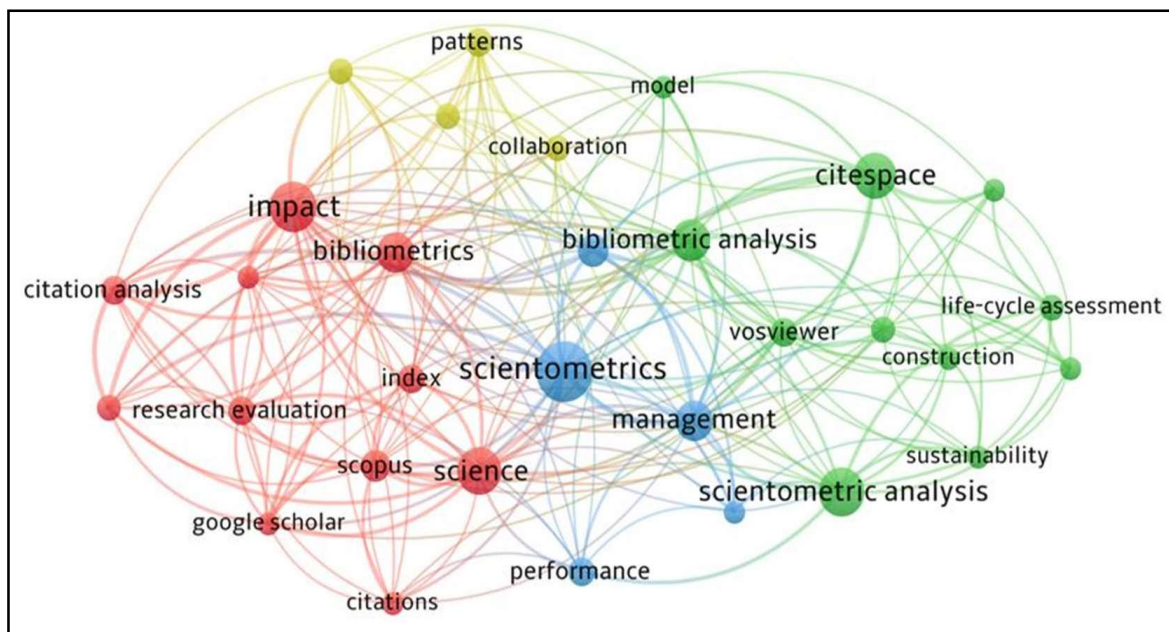


Figure 5. Key-words Co-occurrence Network

5.14. Co-authorship Countries Map-overlay Visualisation

The co-authorship network depicted in Figure 6 illuminates the collaborative efforts among the most productive countries. China's extensive connections with nine countries, with a total link strength of 24, indicate that Chinese researchers have collaborated 24 times with researchers from these nine countries, resulting in a total of 37 publications. Australian researchers have produced 14 publications with a total link strength of 15, indicating collaborations with researchers from five countries. The United States has collaborated with nine countries, with a total link strength of 11, resulting in 37 publications. England has collaborated with seven countries, with a total link strength of 10, resulting in 14 publications.

6. Results

This study focuses on an analysis of the top 100 highly cited research articles in Scientometrics published from 2013 to 2022, as listed in the Web of Science (WoS) database. Among the total of 100 manuscripts, 68 were classified as original articles, 29 were categorised as review papers, only 1 paper was identified as proceedings and 2 as editorial articles. The LEIDEN UNIVERSITY holds the maximum number of papers, i.e., 44. The publication titled "Bibliometrie: Das Leidener Manifest zu Forschungsmetriken" received the most number of citations i.e., 814, and has achieved the top position in terms of citation count. With regards to the frequency of words the term "Impact" has been observed to be the most commonly used word, with a frequency of 18 occurrences over the years 2013 and 2022. In the field of Scientometrics, the year 2020 had a notable level of productivity, with 20 publications, thereby establishing it as the most prolific year in terms of paper output. Out of a total of 377 authors, Thelwal M emerged as the most prolific contributor, having authored five publications out of a hundred. In terms of productivity, China stood out as the leading country, accounting for 28% of the total contributions.

7. Discussion and Conclusion

Scientometrics is a tool for measuring the scientific literature. It helps the scholar to assess any scientific output. On the other hand, bibliometric analysis of the Scientometric papers would help the scholars to easily track the best papers on Scientometrics during the year 20213-2022 based on certain parameters such as most prolific authors, most relevant affiliation, most productive countries etc. The principal objective of bibliographic analysis is to critically examine the extant body of literature pertaining to a specific subject matter, with the aim of acquiring a full comprehension of the topic at hand. In this context the

Note: In Figure 5 a threshold of 5 was applied for 100 profoundly cited scholarly papers, yielding a collective of 31 discernible keywords out of 897 keywords. The magnitude of the bubbles is representative of the overall count of extensively cited articles, whereas the thickness of the connecting lines and their chromatic representation denotes the potency of interrelation and the clustering structure, respectively.

present study reveals that out of 100 papers on scientometrics China is the leading country in terms number of publication produced. The affiliation The LEIDEN UNIVERSITY holds the maximum number of papers, i.e., 44. Year 2020 was the most productive year as it produced 20 publications. To the best of the author's knowledge, as far as the WoS database is concerned, this study is unique in the given period of time. In this way we have done bibliometric analysis of top 100 highly cited papers in the field of Scientometric that will tremendously help the researcher to identify the most relevant literature in the field of Scientometric during the past decade.

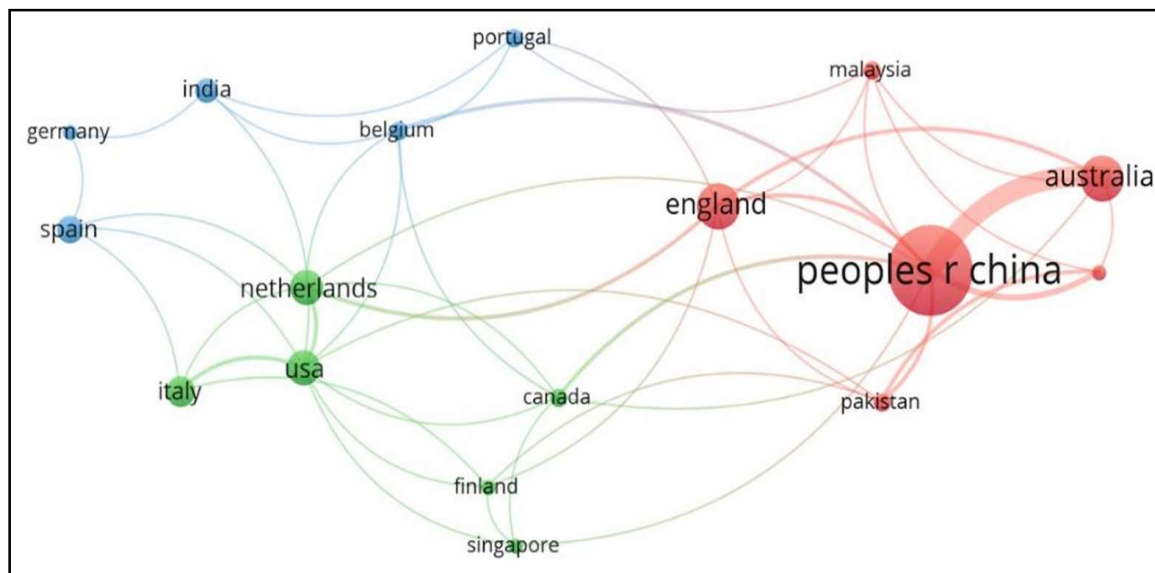


Figure 6. Co-authorship Network

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Note: In Figure 6 a threshold of 3 was applied for 100 profoundly cited scholarly papers, 17 countries met the threshold out of 47 countries. The magnitude of the bubbles is representative of the overall count of extensively cited articles, whereas the thickness of the connecting lines and their chromatic representation denotes the potency of interrelation and the clustering structure, respectively.

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