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Review

Scientometrics of Scientometrics Based on Web of Science Core Collection Data between 1992 and 2020

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Abstract: Scientometrics is a quantitative and statistical approach that analyzes research on certain themes. It originated from information/library science but has been applied in various disciplines, including information science, library science, natural science, technology, engineering, medical sciences, and social sciences and humanities. Numerous scientometric studies have been carried out, but no study has attempted to investigate the overall research status of scientometrics. The objective of this study was to investigate the research status of scientometrics based on 16,225 publications archived in the Web of Science Core Collection between 1992 and 2020. The results show that there has been a marked increase in publications on scientometric studies over the past decades, with "Information Science Library Science" being the predominant discipline publishing scientometric studies, but scientometrics has been widely adopted in a variety of other disciplines (240 of 254 Web of Science categories). It was found that Web of Science, Vosviewer, and *Scientometrics* are the most utilized database, software, and journal for scientometric studies, respectively. The most productive author (Lutz Bornmann from the Max Planck Society, Germany), organization (University of Granada, Spain), and country (USA) are also identified. In addition, high-impact scientometric studies and the research landscape are analyzed through citation networks and the co-occurrence of keywords method.

Keywords: big data; bibliometric analysis; scientometrics; science mapping; VOSviewer; Web of Science; review

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1. Introduction

Scientometrics is a quantitative and statistical approach that reveals the processes of development in science and technology. It serves scientific decision making and management using information that is generally from scientific publications [1–5]. The terminology "scientometrics" ("naukometriya") was coined in 1969 [6] and obtained broad acceptance; it has grown in popularity as the journal *Scientometrics* was established in 1978 [5,7]. Scientometrics is commonly synonymously referred to as informetrics, bibliometry, bibliometrics, bibliometric analysis, science mapping, or knowledge structure in the literature, although these terms are essentially recognized as separate fields [7]. Scientometrics originated in information and library science, but it has evolved over time and has been widely applied in a variety of other disciplines in order to identify research landscapes (e.g., growth, structure, interrelationship, and productivity) or map historical footprints, emerging hotspots, or scholarly fields [8,9]. In addition, it is also a useful practice and tool for training and familiarizing researchers with a new topic or discipline.

Scientometrics is essentially the analysis of big publication data from various sources, such as a certain journal(s), topic(s), or databases (e.g., Web of Science, Scopus, Medline, and Google Scholar). Numerous studies have compared the coverage of databases used for scientometric analysis [10–13], developed new tools or methods [14–17], or focused on its applications in various disciplines [18–29]. However, there is a lack of research on the scientometric analysis of scientometric studies. The objective of this study was therefore to provide both novices and experts with a scientometric overview and visualization of scientometrics based on the Web of Science database over the period from 1992 to 2020.

2. Materials and Methods

The Science Citation Index Expanded (SCI-EXPANDED) and Social Sciences Citation Index (SSCI) of the Web of Science Core Collection (WoSCC) is a complete literature database commonly used for scientometric analysis [11,30]. The data between January 1992 and December 2020 were downloaded from the WoSCC on 10 January 2021 for analysis. A later search shows that only a small number of publications (32) of 2020 were not indexed as of the search date because of the delay in the inclusion of the previous year's publications by the WoSCC. Although this time period does not cover the entire publication history, it would reflect the general trend of scientometric research as the majority of widely used scientometric applications/software were developed after the 1990s. There is no need to include all data from all time periods to reflect the research trend. Therefore, query sets including the key element of scientometric studies, such as synonyms for the names of scientometrics, often-used software tools, and visualization forms, can ensure that the majority of scientometric studies are included in this study.

The query sets used for the literature search are as follows: TS = ("scientometric*" OR "bibliometric*" OR "science mapping" OR "Knowledge structure" OR "co-citation network" OR "co-occurrence analysis" OR "co-authorship analysis" ORn "publication trend" OR "Citespace" OR "VOSviewer" OR "Histcite*" OR "Thomson Data Analyzer" OR "NetDraw" OR "UCINET" OR "BibExcel" OR "CitNetExplorer" OR "Leydesdorff Toolkit" OR "Gephi" OR "Pajek" OR "Notepad++" OR "Sublimetext" OR "Bicomb" OR "Cocites-co-citation tool" OR "Carrot2" OR "Citenetexplorer" OR "CRExplorer" OR "GPS Visualizer" OR "Nails-HAMMER" OR "Jigsaw" OR "KnowledgeMatrix Plus" OR "MapEquation" OR "NodeXL Basic" OR "Open Knowledge Maps" OR "Publish or Perish" OR "BiblioTods" OR "MetaKnowledge" OR "RPYS" OR "reference publication year spectroscopy" OR "Bibliometrix" OR "CITAN" OR "Social Network Visualizer" OR "SATI" OR "Scholarometer" OR "SATI" OR "Scholarometer" OR "ScienceScape" OR "Visone" OR "Voyant Tools" OR "Voyant Tools" OR "WoS2 Pajek" OR "WoS Network Tool" OR "Webometric Analyst"). "TS" is a search term that is short for "topics" in the Web of Science.

The search results were then saved as a text file containing "full record and citation data" for scientometric analysis with Vosviewer 1.6.15 [15] (The Centre for Science and Technology Studies, The Netherlands). The co-authorship networks of authors, organizations, and countries; citation networks of highly cited publications; and density visualizations of keyword co-occurrence were analyzed. For the co-authorship network and citation network, the software only analyzes publications with a maximum of 25 authors per publication by default.

3. Results and Discussion

3.1. Annual Publication Trend and the Distribution of Disciplines

The query sets in Section 2 returned 16,225 scientometric publications between 1992 and 2020. Figure 1 shows that the number of publications increased rapidly from 53 in 1992 to 1455 in 2018. The increasing trend has soared significantly in recent years, with 2005 publications in 2019 and 2517 publications in 2020. It is expected that more scientometric publications will appear in the coming years. This is verified by a later search in Nov. 2023 where years 2021–2023 experienced annual publications of over 4000.

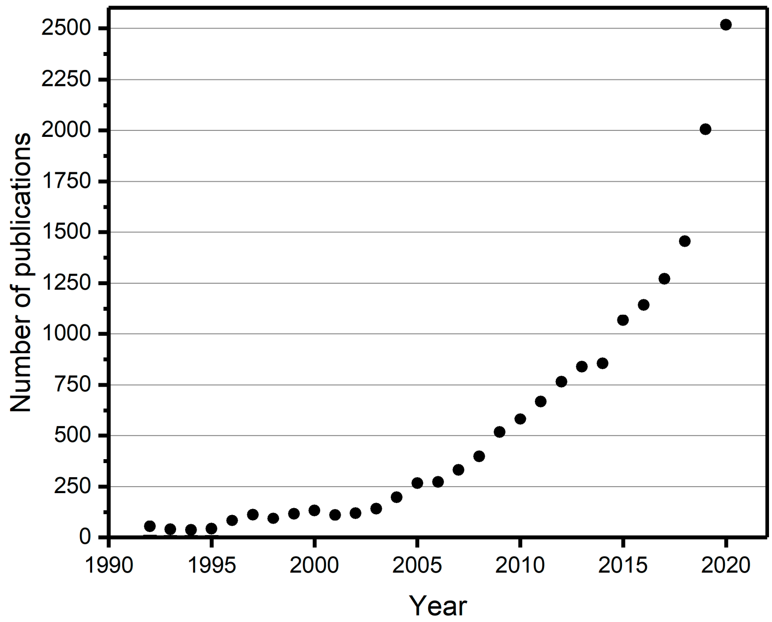
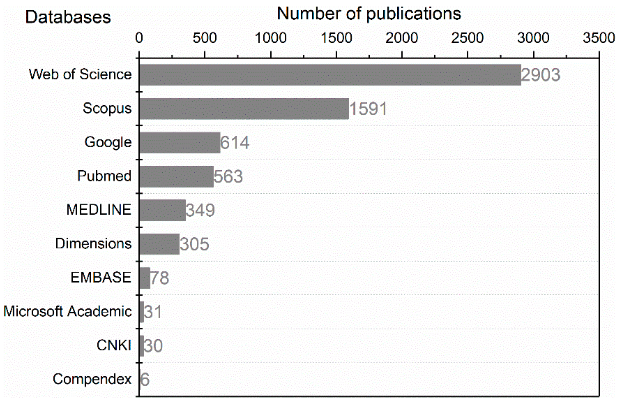


Figure 1. Annual trend of scientometric publications based on the Web of Science Core Collection (WoSCC) databases between 1992 and 2020.

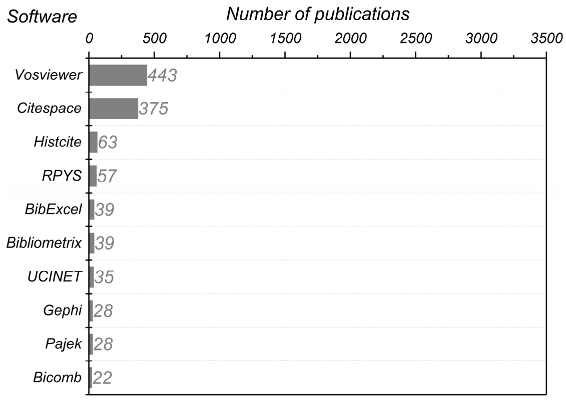
In addition, the majority of these scientometric publications were written in English (N = 15,243, 93.95%; N indicates the number of publications) and published as journal articles (N = 12,777, 78.75%). The 16,225 publications mainly come from SCI-expanded (SCIE) with 12,296 publications, and there is some overlap with the SSCI database that consists of 10,125 scientometric publications. These 16,225 publications cover 240 out of 254 Web of Science categories, and the top three categories are Information Science Library Science (N = 4461), Computer Science Interdisciplinary Applications (N = 2896), and Computer Science Information Systems (N = 1080). These publications can be divided into 148 Web of Science research areas, in which six areas published over 1000 papers: Information Science Library Science (N = 4461), Computer Science (N = 4402), Environmental Sciences Ecology (N = 1315), Business Economics (N = 1296), Science Technology Other Topics (N = 1274), and Engineering (N = 1114). This indicates that scientometric publications predominately comprise traditional computer science or information/library science topics, but it has also been widely applied in a variety of other disciplines to analyze research statuses [18–20].

3.2. Commonly Used Databases, Software, and Journals

Figure 2a shows that Web of Science (WoS), Scopus, and Google Scholar are the routinely used citation databases for scientometric analysis. WoS ranked first, which may be attributed to the fact that WoS is the only practical database to retrieve citation counts up until 2004 when Scopus and Google Scholar were introduced [12]. These databases differ in management, selection criteria, and coverage [31]. For example, WoS and Scopus are curated databases that document inclusion or index publications (e.g., journals, books, and conference proceedings) based on a set of source selection criteria, but they have limited coverage in non-English publications and social science and humanities [10,31]. While Google Scholar adopts an inclusive, unsupervised, and automated approach with robot crawlers to index any scholarly document on academic websites, this results in technical errors, including duplicate entries, incorrect or incomplete bibliographic information, and the inclusion of non-scholarly materials [32]. Pubmed, MEDLINE, Dimensions, and EMBASE, for example, mainly consist of publications pertaining to medical science. Microsoft Academic was first launched in 2019 and has a tool similar to Google Scholar [33,34], and CNKI (Chinese National Knowledge Infrastructure) mainly includes journal papers published in Chinese.



(**a**)



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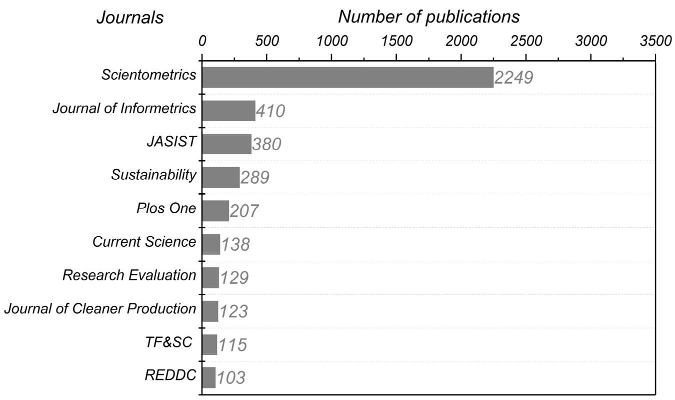

(**c**)

Figure 2. The top 10 databases (**a**), software (**b**), and journals (**c**) for scientometric publications. The search results returned were based on query sets and included the database (e.g., TS = "Web of Science") in combination with the query set used in Section 2. The abbreviations in (**c**) are as follows: TF&SC and REDDC are short for Technological Forecasting and Social Change and Revista Espanola De Documentacion Cientifica, respectively. Note: *Journal of the American Society for Information Science and Technology* (JASIST) was renamed to *Journal of the Association for Information Science and Technology* (JASIS&T or JASIST) in 2013; they were combined and the name JASIST was used.

A great number of computer programs/applications/software listed in the query set in Section 2 has been developed to assist scientometric analysis. These software tools differ in functions, user friendliness, and capability of computations or graphs, and no single tool can be considered to be the best or complete [14]. The top three most utilized software for scientometric analysis are Vosviewer [15], Citespace [16], and Histcite [17] (Figure 2b). All three software programs are freely available, but they differ in ease of use and functions. The

Vosviewer is a cluster-based program and is user friendly, but there is no way to capitalize the words or terms (e.g., names, journals, or countries), and similar keywords cannot be merged for analysis [18,19]. Citespace is written in Java and characterized by many functions, but it is more complex to use. Hiscite was developed for analyzing WOS data, but it is out of service, and a modified version provided by a researcher from Chinese Academy of Science is available for use (HistCite Pro, https://zhuanlan.zhihu.com/p/20902898, accessed on 12 May 2020). The number of application cases for other software is low. It should be noted that the number of scientometric applications in Figure 2b may be underestimated as the search results are only based on the keywords in the title, abstract, and author-provided keyword lists. No full texts were checked for validation as it is challenging to access full texts of over 16,000 publications for this purpose, but the number should reflect the general trend of software preference. In addition, researchers may use citation managers (e.g., Endnote, Mendeley, Refman, Zotero, and bibfilex), Microsoft Excel, Python, or R package to carry out analyses, but these are beyond the scope of this study.

It is not surprising to see that *Scientometrics* is the most utilized journal for publishing scientometric studies (Figure 2c). Many other popular journals, e.g., the *Journal of Informetrics* and the *Journal of the Association for Information Science and Technology* (was *Journal of the American Society for Information Science and Technology*), are from the discipline of information. The open access journals of *Sustainability* and *PLoS ONE* are also often used, with over 200 scientometric publications between 1992 and 2020. The *Journal of Cleaner Production* is the only disciplinary journal that published over 100 scientometric studies. It is noteworthy that 4237 journals published 16,225 scientometric papers, which indicates that scientometrics is integral to research in various disciplines. Figure 2 could also give hints on choosing the right database, software, and journals for future scientometric studies.

3.3. Co-Authorship of Authors, Organizations, and Countries

There are 270 out of 37,871 authors who meet the standards of a minimum of 10 scientometric publications (Figure 3). They consist of 87 clusters of groups of close collaborators, with 127 authors in the largest cluster. The top 10 authors/organizations/countries contributing to scientometric publications are tabulated (Table 1). Dr. Lutz Bornmann from the Max Planck Society, Germany, is the most productive researcher, publishing over 160 papers. There are three other researchers (i.e., Yuh-Shan Ho, Giovanni Abramo, and Ciriaco Andrea D'angelo) who published over 100 papers. The cluster comprising Gangan Prathap from APJ Abdul Kalam Technological University, Thiruvananthapuram, and the Vidya Academy of Science in Figure 3 is far away from the other authors, indicating a weak relatedness. This weak connection among authors in scientometrics is different from the scientometric studies of a certain discipline [18–29], where collaborations between researchers are more common. However, it is understandable that scientometric publications in this study generally focus on topics of different disciplines, and few such studies focus on inter- or cross-disciplinary work.

Table 1. Top 10 authors, organizations, and countries on scientometric publications. N, C, and TLS indicate the number of publications, citations, and total link strength, respectively. Values of TLS change with the number of items included in Vosviewer for analysis, and TLS in the table was calculated when all items were included.

No.	Item	N	C	TLS
Top authors				
1	Bornmann, Lutz (Max Planck Society, Germany)	166	3895	157
2	Ho, Yuh-Shan (Asia University, China)	147	4116	52
3	Abramo, Giovanni (IASI-CNR, Italy)	109	2468	152
4	D'angelo, Ciriaco Andrea (University Roma "Tor Vergata", Italy)	109	2433	153
5	Leydesdorff, Loet (University of Amsterdam, The Netherlands)	93	3969	74
6	Thelwall, Mike (University of Wolverhampton, UK)	62	2358	26
7	Glanzel, Wolfgang (Katholieke University Leuven, Belgium)	59	1048	58
8	Groneberg, David A. (Goethe University Frankfurt, Germany)	58	603	196
9	Merigo, Jose M. (University of Chile, Chile)	58	1920	33
10	Lariviere, Vincent (University of Montreal, Canada)	56	3327	100

Table 1. *Cont.*

No.	Item	N	C	TLS
Top organizations				
1	University of Granada (Spain)	278	5787	242
2	Leiden University (The Netherlands)	218	12,207	168
3	Chinese Academy of Science (China)	192	2488	267
4	University of Valencia (Spain)	188	2050	224
5	Katholieke University Leuven (Belgium)	163	4166	249
6	Consejo Superior de Investigaciones Cientificas CSIC (Spain)	161	3489	155
7	Asia University (China)	151	3762	137
8	Wuhan University (China)	145	1909	115
9	Indiana University (USA)	139	6801	178
10	Peking University (China)	137	3287	167
Top countries				
1	USA	3146	75,166	2291
2	China	2575	28,533	1460
3	Spain	1705	24,791	984
4	UK	1295	29,200	1456
5	Germany	1045	17,293	948
6	Brazil	808	6541	308
7	Australia	803	13,726	775
8	Italy	790	14,139	664
9	Canada	708	15,070	633
10	The Netherlands	642	25,999	643

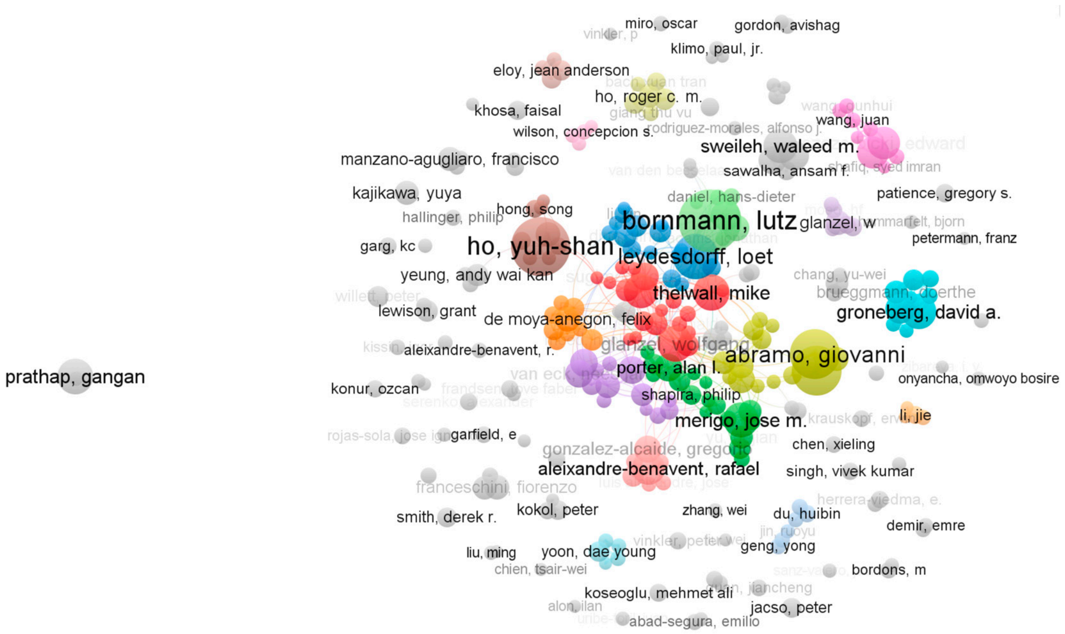

Figure 3. Co-authorship network map of authors meeting the threshold of 10 publications per author (produced with the Vosviewer).

In addition, there are 652, 307, 178, and 77 out of 9,040 organizations publishing a minimum of 10, 20, 30, and 50 scientometric papers, respectively. Among the top 10 contributing organizations, there are three organizations from Spain (i.e., University of Granada, University of Valencia, and Consejo Superior de Investigaciones Cientificas CSIC) and four universities or institutes from China (i.e., Chinese Academy of Science, Asia University, Wuhan University, and Peking University), as indicated in Table 1. The Chinese Academy of Science ranked third in total publication volume but ranked first for TLS, which indicates that they have stronger collaborations with other organizations. It should be noted that the top ten organizations are different from the Web of Science records, where Consejo Superior de Investigaciones Cientificas (CSIC) ranked first, followed by the University of Granada, Chinese Academy of Sciences, University of London, Leiden University, Max

Planck Society, University of California System, University of Valencia, University System of Georgia, and KU Leuven. The publication volume of each organization is higher in the Web of Science as well. However, the data of Vosviewer were kept because the citations and total link strength are provided.

Furthermore, there are 148 countries that published scientometric studies, with 91, 75, 63, 55, 49, 25, and 12 countries meeting the threshold of 5, 10, 20, 30, 50, 200, and 500 papers, respectively. Five countries (i.e., USA, China, Spain, UK, and Germany) contributed over 1000 scientometric papers in total (Table 1). Compared to other countries, the USA, China, and the UK had a greater TLS, which indicates more international collaborations.

3.4. The Highly Impacted Studies

There are 1171 publications that meet the threshold of a minimum of 50 citations, with 309 clusters or groups of closely related publications. The largest cluster consists of 850 papers, which is shown at the center of Figure 4. Among them, the publication by Rodriguez and Laio [35], who developed cluster analysis to classify items into categories based on their similarity, is the most highly cited paper (the biggest circle), with C = 1745 citations until 10 January 2021, as recorded by the WoS. However, it is noted that this paper was seldom cited by scientometric studies as most generally use the scientometric software program that already incorporates this function. The studies that introduce the popular scientometric software programs, Vosviewer [15] and Citespace [16], are also highly cited at C = 1734 and 1094, respectively. Cobo et al. [14], who evaluated nine scientometric software programs, were also highly cited (C = 479). Study [36], which compared the coverage of databases such as WoS, Scopus, and Google Scholar, was also frequently referenced. The papers on the outer circle of Figure 4 generally focus on the research analysis of a certain research field or theme [37–41]. They are grayed out as there is an insufficient number of colors in the software to differentiate them. It is noteworthy that the majority ofscientometric studies were cited less than 50 times. The exclusion of these studies does not necessary mean that they are not important, but because they were published more recently, there is only a small research community, or the topic is not an emerging theme with attractions, etc.

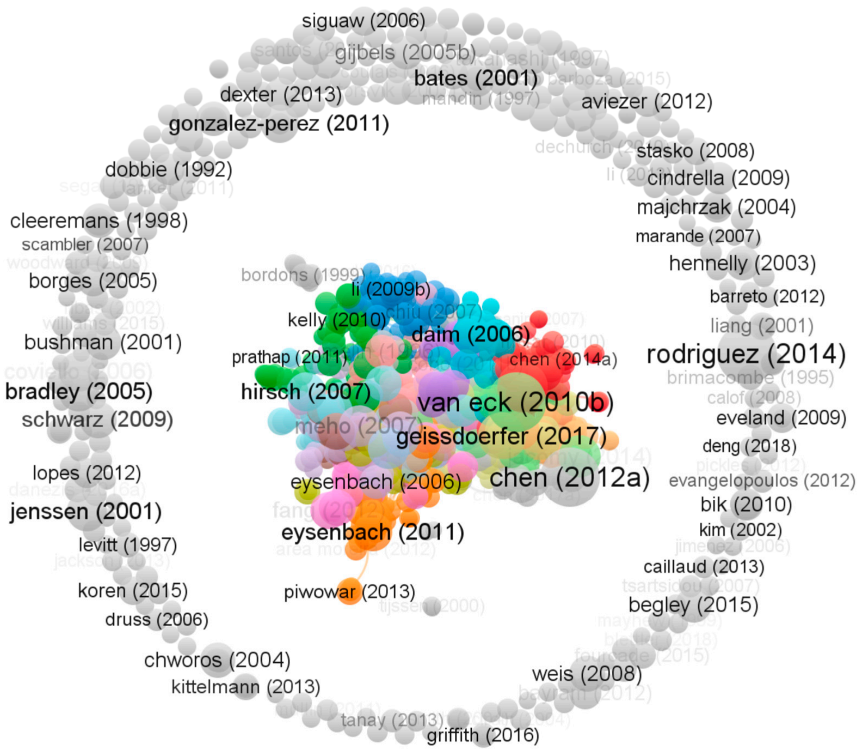

Figure 4. Citation network of publications with a minimum of 50 citations.

3.5. Co-Occurrence Analysis of Keywords from the Title, Abstract, and Author-Provided Keywords

Vosviewer extracted 42,206 keywords from the title, abstract, and author-provided keywords. There are 827 meeting the minimum of 20 keyword occurrences, and they consist of five clusters (Figure 5a). Each cluster represents a group of related research studies. For instance, the red-colored cluster focuses on analyzing research trends based on "Web of Science" ("SCI-expanded") or "Pubmed" using "Citespace" or similar tools. Most research is from medical science, as indicated by keywords including "medicine", "cancer", "diagnosis", "gene", "pain", and "acupuncture". The blue-colored cluster focuses on the analysis of "research impact", as indicated by keywords such as "citations", "h-index", "Google scholar", "indicators", etc. The top 50 keywords with the highest occurrences can be found in Table 2. There are 286 keywords in the author-provided keyword list that meet a minimum of 20 occurrences, and they comprise nine clusters/colors (Figure 5b). "Bibliometric(s)", "bibliometric analysis", and "scientometrics" are the most commonly appearing keywords (Figure 5b and Table 2). The scientometric method was used to carry out "citation analysis", "social network analysis", "co-word analysis", and "co-authorship" or "collaboration" or "scientific collaboration" and analyze "research trends", "scientific production", "research productivity", "impact", and "innovation" for example. Scientometrics are always performed with "systematic review" or "review", similarly to the findings in Section 3.2 or Figure 2.

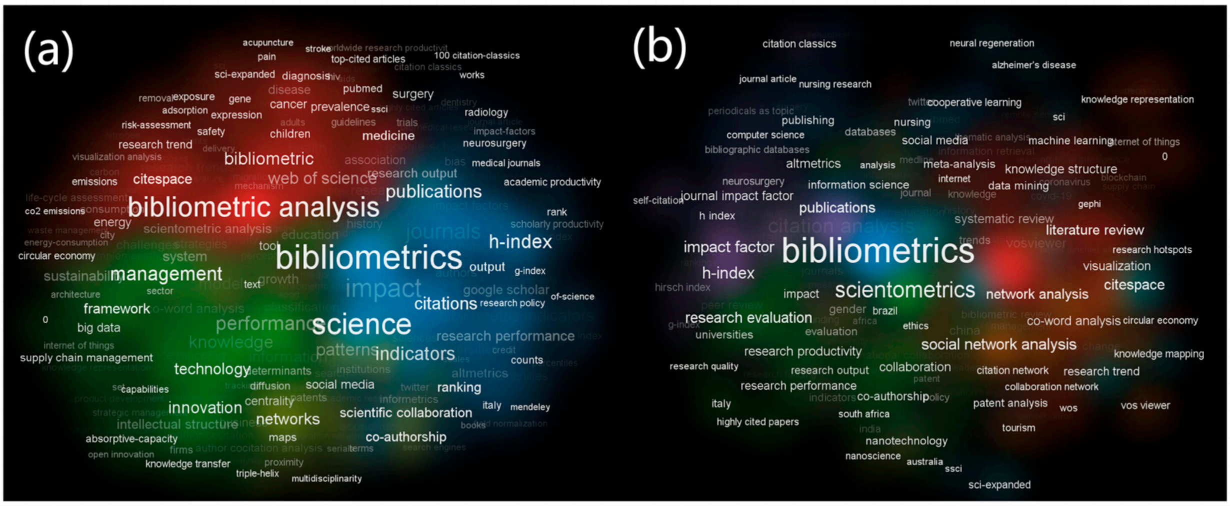

Figure 5. Cluster density visualization for the co-occurrences of keywords in the title, abstract, and author-provided keyword list (**a**); author-provided keywords only (**b**) with a minimum of 20 occurrences. The number of co-occurrences of n keywords indicates the number of publications in which all n keywords occur together. Font size and density (background color) of keywords are used to represent the total link strength (TLS). Greater font size indicates greater TLS, while the distance between each keyword indicates the relatedness of these research topics.

Table 2 illustrates that "Web of Science" and "Scopus" are the two commonly used databases, while "Citespace" and "Vosviewer" are the two most utilized scientometric software programs. It also echoes Table 1 in that "USA", "China", and "Spain" are the main contributors to scientometric studies. Moreover, the software may sometimes have difficulty extracting the right and meaningful keywords, such as "web", "science", "system", and "model" in "all keywords" of Table 2 as there is no specific format or punctuation to separate keywords.

Table 2. Top 50 keywords with greatest occurrences in 16,225 scientometric publications. OC and TLS indicate the number of occurrences and total link strength, respectively. Values of TLS change with the number of items included in Vosviewer for analysis, and TLS in the table was calculated when all items were included.

No.	In All Keywords			In Author Keywords		
	Keyword	OC	TLS	Keyword	OC	TLS
1	bibliometrics	3225	16,582	bibliometrics	3022	6843
2	science	2247	13,806	bibliometric analysis	1478	2748
3	bibliometric analysis	2067	11,299	scientometrics	930	2208
4	impact	1653	10,484	citation analysis	740	1917
5	citation analysis	1049	6377	bibliometric	516	1114
6	scientometrics	1024	5392	Web of Science	448	1369
7	journals	961	6131	h-index	381	1040
8	performance	757	5076	impact factor	328	899
9	h-index	732	4400	citations	308	873
10	management	697	4647	social network analysis	285	620
11	indicators	673	4104	research	266	713
12	citation	659	4190	Scopus	260	894
13	publications	604	3837	research evaluation	256	762
14	trends	569	3675	Citespace	243	598
15	impact factor	561	2975	publications	228	640
16	citations	547	3237	network analysis	206	451
17	collaboration	531	3527	literature review	201	452
18	Scopus	530	3858	citation	188	602
19	knowledge	523	3225	bibliometric indicators	179	412
20	bibliometric	516	2991	Vosviewer	170	471
21	patterns	501	3348	sustainability	169	463
22	web	459	3286	research trends	155	382
23	index	457	2651	text mining	153	410
24	quality	457	2904	scientific production	145	393
25	innovation	456	3379	altmetrics	140	421
26	model	448	2591	China	140	339
27	Web of Science	448	2914	science mapping	140	376
28	bibliometric indicators	439	2480	bibliometry	139	278
29	publication	423	2717	co-word analysis	136	375
30	productivity	412	2870	bibliometric study	130	207
31	networks	394	2567	co-citation analysis	125	308
32	evolution	392	2657	review	124	271
33	technology	388	2622	collaboration	121	299
34	information	382	2344	research productivity	121	352
35	articles	373	2527	knowledge structure	119	118
36	China	363	2261	journal impact factor	116	336
37	social network analysis	317	1808	scientometric analysis	115	199
38	systems	292	1799	systematic review	112	236
39	field	286	1982	content analysis	109	274
40	research productivity	285	2039	visualization	103	284
41	health	280	1583	co-authorship	99	274
42	research performance	270	1807	peer review	97	230
43	sustainability	270	2004	scientific collaboration	97	254
44	research	266	1498	journals	95	318
45	framework	256	1716	impact	91	320
46	research evaluation	256	1663	publication	91	220
47	system	254	1369	innovation	89	250
48	Citespace	253	1579	research trend	89	211
49	network analysis	253	1569	Spain	86	297
50	design	232	1211	gender	85	237

4. Conclusions and Perspectives

This study investigated the research status of scientometric studies based on 16,225 publications archived in the Web of Science Core Collection between 1992 and 2020. The results show that there is an increasing publication trend with respect to scientometric studies over the period investigated: from ~50 papers in 1992 to over 2500 papers in 2020. This shows that the "Information Science Library Science", "Computer Science Interdisciplinary Applications", and "Computer Science Information Systems" categories of the Web of Science are the predominant disciplines publishing scientometric studies. However, it is noteworthy that scientometrics has been widely adopted in various other disciplines as the 16,225 publications cover 240 out of 254 Web of Science categories. This may also indicate that scientometricians may publish in multiple different fields, and there are professionals and organizations whose main duties are scientometric analysis in some countries. It was found that Web of Science, Vosviewer, and Scientometrics are the most utilized database, software, and journal for scientometric studies, respectively. The most productive author (Lutz Bornmann from the Max Planck Society, Germany), organization (University of Granada, Spain), and country (USA) were also identified. The citation network and co-occurrence of keywords were used to analyze high-impact scientometric studies and the landscape of research fields.

None of the most commonly used bibliographic databases (e.g., Web of Science, Scopus, Google Scholar, Microsoft Academic, and Dimensions) could cover complete scientific publications pertaining to a topic of interest [10,11,31,36], and these databases differ from each other in many aspects (e.g., coverage, format, and content). Therefore, the majority of scientometric studies were generally based on one database and may lose or misuse information (e.g., the use of initials for the first name in Scopus may be conflated with authors who have the same initials, which is especially apparent for Asian researchers). However, this issue cannot be solved until protocols between databases are established or specified software is developed. In addition, the preprocessing of downloaded files (e.g., removal of duplicates and the adjustment of full names or short names of authors and organizations) from citation databases is a critical step for any scientometric software programs [14]. Moreover, most databases (e.g., Web of Science and Engineering Village) only allow users to download a certain number of bibliographic references at a time (e.g., it was 500 for Web of Science and now up to 1000 for Web of Science and 2000 for Scopus for each download), which increases the workload of users. At present, there is no single software application that can be used to carry out a complete scientometric analysis [14], nor is it possible that multiple databases can be combined to carry out analyses together. A combination of multiple software tools or separate database-dependent analysis is feasible at the moment [18,42]. The future development of more powerful and user friendly scientometric software tools is therefore recommended. With an increase in the adoption of artificial intelligence—AI (e.g., ChatGPT, GPT4, LLaMA series, ChatGLM series, PaLM series, Gemini, AlphaGo, and Inflection, Falcon)—it is expected that the production of scientometric analysis and writing will be automated.

It is noteworthy that scientometrics would be a good tool or practice for obtaining a picture of a specific research topic or discipline, but this is less likely accepted by disciplinary journals that have strict demands with respect to novelty and scientific contributions. For disciplines other than "Information Science Library Science", "Computer Science Interdisciplinary Applications", and "Computer Science Information Systems", combining scientometric analysis with literature reviews, systematic reviews, or meta-analysis rather than only performing scientometric study is recommended [43]. In addition, scientometrics should play an increasingly more important role in quantifying scientific research personnel and achievements or in decision making as part of research excellence frameworks in countries, including the UK and China [4], because it accounts for references beyond journal articles. Evaluation panels are explicitly forbidden to consider impact factors, index lists, rankings, or the perceived standing of journal publishers in which publications appear, although publications are still a key part of assessing the quality of research outputs. However, a protocol or standardized procedure should still be established for the analysis.

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