

Article

Towards a Bibliometric Mapping of Network Public Opinion Studies

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Abstract: To grasp the current status of network public opinion (NPO) research and explore the knowledge base and hot trends from a quantitative perspective, we retrieved 1385 related papers and conducted a bibliometric mapping analysis on them. Co-occurrence analysis, cluster analysis, co-citation analysis and keyword burst analysis were performed using VOSviewer and CiteSpace software. The results show that the NPO is mainly distributed in the disciplinary fields associated with journalism and communication and public management. There are four main hotspots: analysis of public opinion, analysis of communication channels, technical means and challenges faced. The knowledge base in the field of NPO research includes social media, user influence, and user influence related to opinion dynamic modeling and sentiment analysis. With the advent of the era of big data, big data technology has been widely used in various fields and to some extent can be said to be the research frontier in the field. Transforming big data public opinion into early warning, realizing in-depth analysis and accurate prediction of public opinion as well as improving decision-making ability of public opinion are the future research directions of NPO.



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Keywords: network public opinion; knowledge base; research hotspots; bibliometrics

1. Introduction

Due to the rapid development of the Internet worldwide, online media has become the “fourth media” after newspapers, radio and television [1]. Nowadays, network public opinion (NPO) gradually affects our work, study and life [2]. It has obvious features compared with traditional public opinion. Firstly, the speed of dissemination is fast. Social opinion disseminated through the Internet can basically be generated and disseminated at the same time, which is quite instantaneous. Secondly, because of the openness, interactivity and timeliness of NPO, it has higher degree of attention, wider spread and more influence. Although NPO has many advantages, the anonymity of Internet communication gives lawless elements an opportunity to take advantage of it, not only providing them with convenient communication tools, but also allowing them to evade their legal responsibilities. In recent years, with the development of information technology, the Internet has become an important public opinion channel to express public interests, emotions and thoughts. Once an unexpected event (e.g., COVID-19, Tianjin Port 8·12 Explosion Accident, etc.) is encountered, social opinion will spread on a large scale through the Internet. Due to the spatial and temporal flexibility of the Internet and the transparency of information, viewpoints of different areas and backgrounds are easily expressed through NPO, which has a significant impact on the social economy and people’s lives [3]. Therefore, research on the dissemination of NPO is very necessary.

For the development of NPO, various scholars have made corresponding research at different stages. Before 2000, scholars had not formed a complete system for the study of NPO, their understanding of it was still in the initial stage. At that stage, the Internet

was one of the media for searching and obtaining data, most of them wanted to further use the Internet to collect more extensive and effective data through technical means. The study pointed to the immaturity of the Internet in terms of its ability to assist in secondary analysis, hoped that the ability to store and analyze data can be improved in the future through desktop technology [4]. From 2000 to 2015, with the continuous maturity of Internet technology, scholars continued to deepen their understanding of NPO. SARS, an acute respiratory infection caused by the SARS virus, occurred in Guangdong, China, in 2002 and gradually became a global epidemic in less than a year. To study the spread of SARS, outbreak patterns, predict future transmission dynamics, assess disease prevention and control, vaccine development and other intervention strategies to combat the epidemic, scholars have addressed this problem by constructing a web-based simulation system for epidemic dynamics [5]. Other studies have pointed out that by modeling the regulatory network of SARS, the regulatory patterns associated with SARS can be obtained and SARS anomalies can be monitored, early prediction of SARS can be effectively achieved by this method [6,7]. Future research focused on designing different nonlinear transformations and network optimization methods for a more comprehensive regulation of SARS [8–10]. Other scholars have mainly investigated the correlation and causality between opinion frames and media frames [11,12]. NPO is more likely to amplify some events, and even turn local events into national events, which has an important influence on subsequent media coverage in terms of frame building. With the advent of the era of big data in recent years, the main research direction of researchers is to analyze the opportunities and challenges faced by NPO in the era of big data. The study indicated that the accuracy of public opinion assessment and prediction can be improved by constructing models, and also better avoiding the problems of gradient disappearance and over-fitting [13].

In general, it seems that researchers have carried out a deal of research and obtained some results in using Internet analysis capabilities, studying the connection between opinion frames and media frames, improving the accuracy of NPO assessment and prediction through technical means. Silva et al. [14] found that with the dynamic expansion of research frontiers and knowledge base, the output of science to public opinion is increasing through the study of bibliometric methods. Li et al. [15] studied the impact of NPO on enterprise management, and the study pointed out that the monitoring, evolution and management of NPO play a crucial role in the healthy development of enterprises. In addition, the researcher analyzed the characteristics of the research topic, mined the rules and summarized the research results to provide reference for the next research. Wang et al. [16] revealed the development of NPO in the field of doctor-patient relations, focusing on the medical and health technology fields. The distribution of the research follows Bradford's law of scattering. Liu et al. [17] conducted a study on spontaneous combustion disasters through bibliometric methods. However, at this stage, there is less discussion of knowledge mapping analysis of NPO communication development from a bibliometric perspective, and a lack of comprehensive analysis of research development dynamics in this field [18]. Bibliometric analysis is a powerful analysis tool for researchers, and information visualization software is used by many researchers to perform co-occurrence analysis, keyword burst analysis and co-citation analysis on the current status of research [19,20]. In this paper, we visualized and analyzed the literature related to NPO by bibliometric methods with the help of VOSviewer [21] and CiteSpace [22] to visually analyze the literature related to NPO. It is hoped that it can provide a clearer line of development for later scholars to study the field related to NPO.

2. Materials and Methods

2.1. Data Source

The SCI-E, SSCI, A&HCI and CPCI-SS were elected in Web of Science as the target database for source document retrieval. Two search formulas were set as TS = "public opinion" AND TS = "network" and TS = "public opinion" AND TS = "internet", and 841 and 725 documents were retrieved, respectively. The time span was set to 1990–2020 (as of

31 December 2020), and the final 1385 search records were obtained after a combined search of the two search forms. Among the 1385 papers, there were 6 types of literature. As shown in Table 1, Article 868 (62.67%) was the most frequent type of literature. Proceedings Paper 495 (35.74%) was the second most frequent type of literature. The other four literature types and numbers were “Review” (28), “Early Access” (26), “Editorial Material” (8) and “Meeting Abstract” (6).

Table 1. Types of retrieved documents.

Rank	Type of Document	TP	SOTC	CA	Proportion/%	h-Index
1	Article	868	13,049	11,724	62.67	54
2	Proceedings Paper	495	1334	1294	35.74	14
3	Review	28	617	617	2.02	13
4	Early Access	14	8	8	1.88	2
5	Editorial Material	8	108	108	0.58	4
6	Meeting Abstract	6	0	0	0.43	0

TP: Total Publications; SOTC: Sum of Times Cited; CA: Citing articles.

As shown in Figure 1, the analysis of the six literature types at different time periods shows that the number of publications of all literature types was low before 2004, and began to increase gradually after 2004, showing a stable development from 2015 to 2020. Article and Proceedings Paper have always been the most frequent literature types.

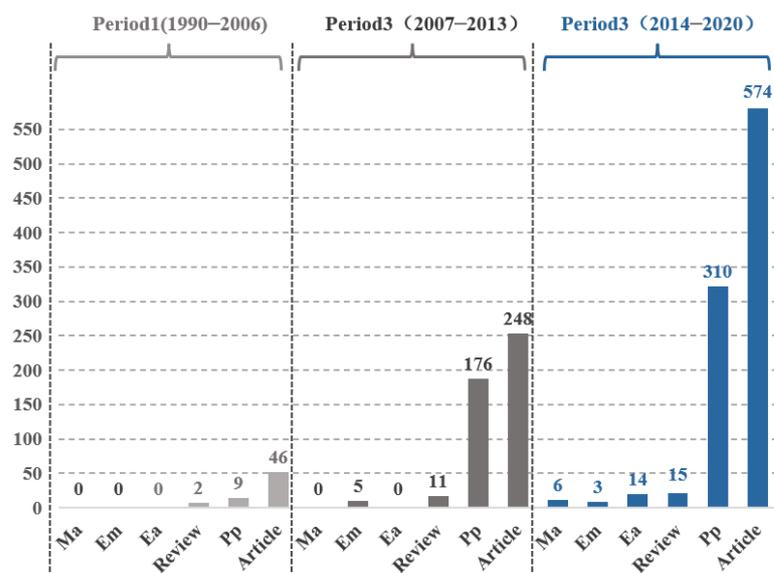


Figure 1. The number of retrieved documents by type and period of publication.

2.2. Method

2.2.1. Theoretical Basis

A bibliometric and visual analysis method was used to analyze 1385 documents using the visualization software VOSviewer [23] and CiteSpace [24] for co-occurrence analysis, cluster analysis, co-citation analysis and keyword burst analysis, based on the following theory.

Experts in the field of knowledge mapping believe that studying the knowledge base of the field can further elucidate the nature of the research frontier [24–26]. If we define a research front as the state of the art of a specialty (i.e., a line of research), what is cited by the research front forms its intellectual base. A specialty can be conceptualized as a time-variant mapping $\Phi_{(t)}$ from $\Psi_{(t)}$ its research front to its intellectual base $\Omega_{(t)}$.

$$\Phi_{(t)}: \Psi_{(t)} \rightarrow \Omega_{(t)} \tag{1}$$

The goal of our research is to develop a general method for detecting and visualizing emerging trends and mutations in $\Phi_{(t)}$ over time. $\Psi_{(t)}$ is a group of words and phrases associated with emerging trends and sudden changes at time t . These terms are called research-front terms. $\Omega_{(t)}$ consists of groups of articles cited by articles in which research-front terms were found. The following notions summarize these relations, for example, S_{title} denotes a set of title terms; $IsHotTopic(term, t)$ denotes a Boolean function, and $article_0 \rightarrow article$ denotes that $article_0$ cites $article$.

$$\Psi_{(t)} = \left\{ term \mid term \in S_{title} \cup S_{abstract} \cup S_{descriptor} \cup S_{identifier} \wedge IsHotTopic(term, t) \right\} \quad (2)$$

$$\Omega_{(t)} = \left\{ article \mid term \in \Psi_{(t)} \wedge term \in article_0 \wedge article_0 \rightarrow article \right\} \quad (3)$$

2.2.2. Research Methodology

As shown in Figure 2 of this paper, the bibliometric analysis was divided into three steps: bibliometric search, bibliometric analysis, and qualitative discussion. Firstly, we searched 1385 relevant literatures in the field of NPO in the Web of Science core database (Step 1), and then used the visualization software VOSviewer and CiteSpace to conduct bibliometric analysis of 1385 literatures including: co-occurrence analysis, cluster analysis, co-citation analysis and keyword burst analysis (Step 2). Finally, the results of the analysis were discussed qualitatively (Step 3).

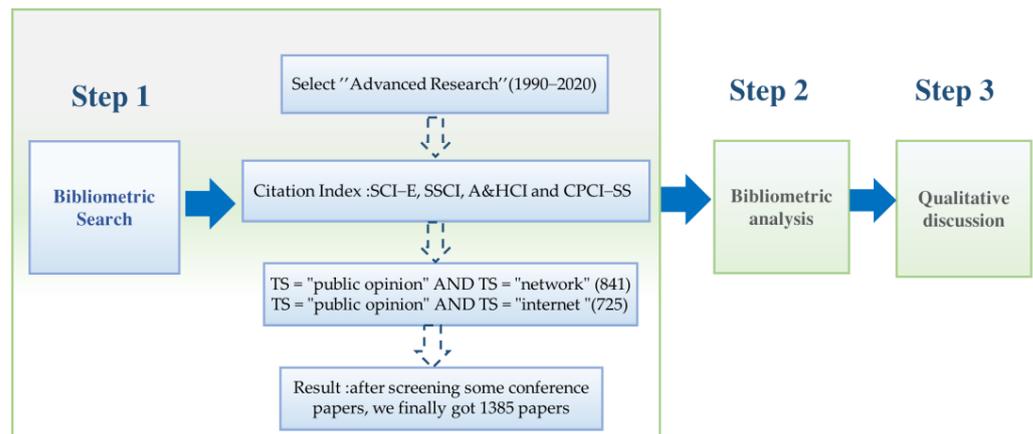


Figure 2. Research methodology of NPO.

3. Results and Discussion

3.1. Temporal Distribution Map of the Literature

3.1.1. Temporal Distribution of World Literature

The number of papers related to the field of NPO research retrieved from the WOS core database is 1385 (1990–2020), and the distribution of the number of papers and the 3 stages of development can be seen in the Figure 3.

Initial stage (1990–2006): From 1990 to 2006, the annual volume of literature in this field was relatively low, with the highest year being only 14 articles. This indicates that relevant research is just starting at this stage. At this stage, the subject of the research is mainly to obtain people’s objective views of the government and the use of the Internet through public opinion surveys and telephone surveys. Iyengar and Si [27] pointed out that the combination of public opinion surveys and the nature of information sources will help rationalize the government’s view of the crisis. Huckfeldt et al. [28] described that the consequences of the public opinion environment depend on the existence of citizens exposed to the micro-environment of the surrounding public opinion distribution, he revealed the construction of a civil social network acts as a filter for the macro environment of government information. Katz and Aspden [29] conducted a telephone survey on the

use of the Internet. The survey results show that social and work networks seem to play an important role in stimulating people’s interest in the Internet and providing support to users. It can be seen that the focus of the early field is focused on the use of the Internet and the objective evaluation of the government.

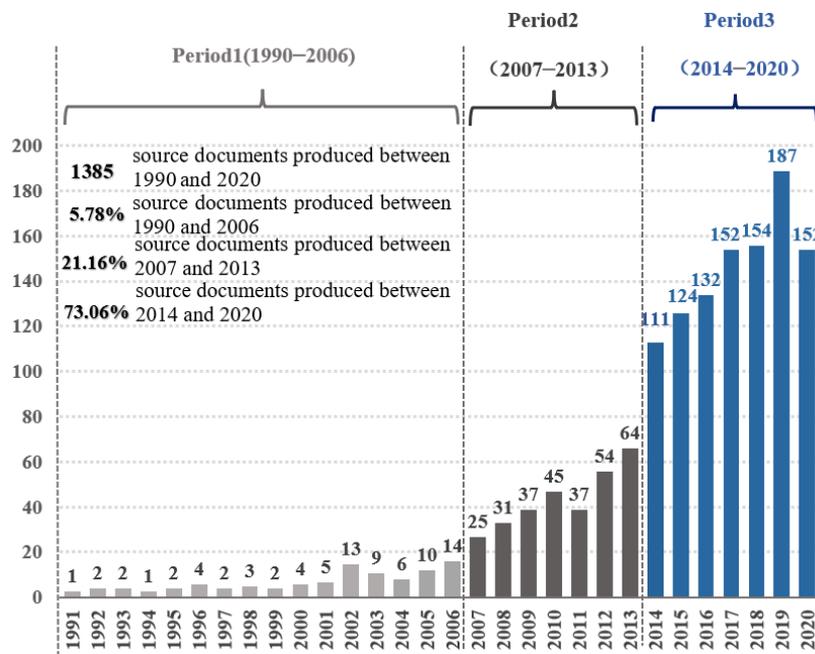


Figure 3. Publication growth trend around the world.

Rapid development stage (2007–2013): During the period from 2007 to 2013, the annual literature volume was distributed more regularly, with a stepwise increase in the annual literature volume compared to the previous phase and a more stable development overall. It can be considered that the field of NPO research has entered a developmental stage. At this stage, earlier articles mainly discussed the relationship between NPO and politics. The power of online media is growing at this stage [30].

Stable growth stage (2014–2020): From 2014 to 2020, the minimum number of documents is 111 (2014), and the highest number of documents has increased to 187 (2019), showing a steady growth overall. This reflects scholars are entering deeper into the field of NPO and entering a phase of in-depth exploration. At this stage, relevant research in the field of NPO is increasing and maintaining a steady growth trend. It can be considered that NPO has entered a stage of steady growth. With the advent of the era of big data, the widespread use of various social media has promoted the rapid development of public opinion. Due to the prevalence of social media and the fluidity of public opinion, the public will be informed of most of the information related to unexpected public events, and they can express their opinions about what is going on as well as their own views. Therefore, the characteristics of crisis communication of social media and the role of the Internet and social media in crisis communication are the focus of research at this stage [31]. The research argued that based on the multi-agent NPO dissemination model, the study of the crisis information release strategy of the mass media to control the public panic caused by emergencies [32]. In recent years, research hotspots have tended to diversify. Since the outbreak of COVID-19 in Wuhan, China, there was an increasing amount of discussion about this outbreak on major social media. Almost everyone was following the latest developments in the outbreak. However, when the Internet is flooded with information that is hard to distinguish from the truth, it is a challenge for the government to control the direction of public opinion and for the public to not believe rumors and not spread them [3]. The advent of the Internet era has diversified the outbreak of NPO events [33]. The current research direction is mainly to measure the public’s attention to prominent public health

events through social media. By collecting information on social media, we can know the questions that the public is more concerned about the outbreak. For example, “Do I need to wear mask even at home during the outbreak?” “Does Shuanghuanglian really have an antiviral effect?” Once this information is collected, it will help the government and health authorities to communicate with the public about these issues, which will not only be relevant but also prevent the spread of COVID-19 [34].

3.1.2. Temporal Distribution of Active National Literature

The top four countries in terms of article publication were China, the United States, the United Kingdom, and Canada. As shown in Figure 4 we have conducted a comparative analysis of the distribution pattern of articles in each country over time. The top four countries show an increase in literature publication, with the UK and Canada showing a similar number of publications and growth rates. Compared with these two countries, the United States showed a greater growth rate, while China did not until 2007. However, since 2009, China has surpassed the US in terms of the number of publications.

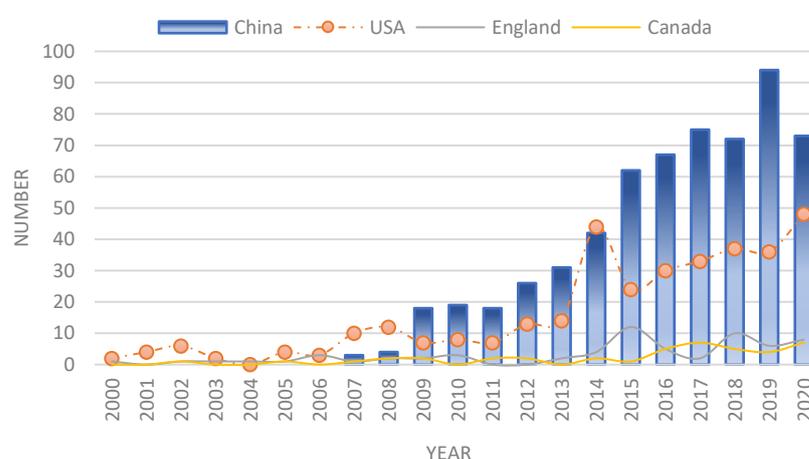


Figure 4. Publication growth trend of 4 countries (China, USA, England, Canada).

3.2. Spatial Distribution Map of the Literature

3.2.1. Country/Region Distribution

VOSviewer analysis shows that a total of 65 countries (regions) have published papers related to NPO research, from which the 10 countries with the highest total number of publications were extracted. ACI (average citation volume) indicates the average publication volume, and h-index is an indication of paper impact. The size of influence, total link strength represents the frequency of cooperation between countries. From Table 2, we conclude that most of the articles originate from developed countries, and among the top 10 countries with the most published articles, the three countries with the highest ACI are Germany, the United States, and Italy. The United States and Germany also lead in the number of papers. Although China has the highest number of papers in the world, the ACI is only 3.14, indicating that there is still much room for development.

A total of 65 countries were analyzed by VOSviewer to show the research network opinion, countries with less than 5 articles were excluded, the remaining 39 countries' information was used to draw the cooperation network (see Figure 5). Each node in the figure represents a country, the size of the node is proportional to the number of articles published in that country, the thickness of the line between nodes represents the intensity of cooperation between countries. As shown in Figure 5, China is the most active in the field of NPO research, followed by the United States, the United Kingdom, Canada and Germany; China (71) has the highest total linkage cooperation intensity with the United States (116), and also cooperates frequently with various countries.

Table 2. Top 10 productive countries in NPO studies, 1990–2020.

Rank	Country	Region	Quantity	Percentage/%	ACI	h-Index	Total Link Strength
1	China	East Asia	604	43.61	3.14	20	71
2	USA	North America	355	25.63	21.02	44	116
3	England	Western Europe	66	4.77	14.61	16	67
4	Canada	North America	43	3.11	14.47	12	35
5	Germany	Central Europe	34	2.46	25.35	14	13
6	Spain	Southern Europe	33	2.38	13.91	10	12
7	Australia	Oceania	32	2.31	15.97	11	37
8	Italy	Southern Europe	31	2.24	18.87	10	25
9	South Korea	East Asia	29	2.10	14.34	10	17
10	India	South Asia	23	1.66	1	3	5

ACI: Average Citations per Item.

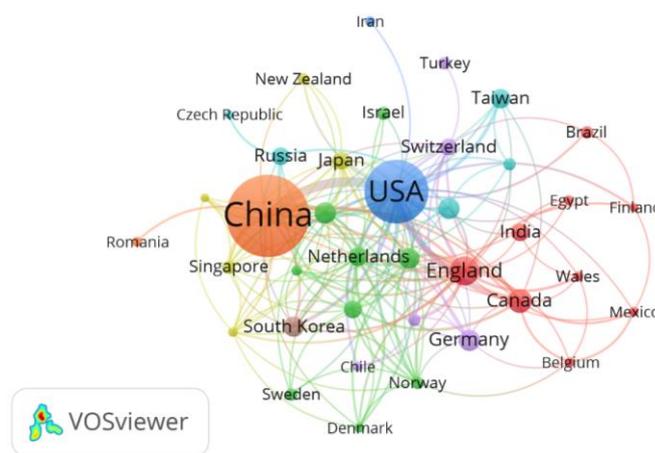


Figure 5. Cooperation countries in NPO studies, 1990–2020.

3.2.2. Disciplinary Distribution of Literature

We obtained the disciplinary distribution in the field of NPO by using CiteSpace. The literature in this field is distributed among 97 disciplines, of which we counted the top 10 disciplines, as shown in Table 3. Quantity indicates the volume of literature; centrality means the degree of centrality; and percentage indicates the proportion of literature in the discipline. Among these 20 categories, the highest centrality is in Computer Science, Information Systems (0.51), Computer Science (0.41), and Engineering, Electrical and Electronic (0.31), which means they are the key hubs of the research area. In addition, Computer Science ranked first in terms of the number of articles published, with 455 articles, accounting for 32.85% higher; next was Engineering, with a total of 271 articles (19.57%); followed by Computer Science, Information Systems (16.03%), Computer Science, Theory and Methods (15.16%), Communication (13.57%), Engineering, Electrical and Electronic (13.43%). The distribution of disciplines reflects that “computer science”, “engineering”, “information system” and “theoretical methods” are the foundation for the development of NPO and important tools to promote the development of NPO. “Communications”, “Engineering, Electrical and Electronics”, “Government and Law” and “Politics” are the external environments that ensure the healthy development of NPO. “Artificial intelligence”, “telecommunications” and “interdisciplinary applications” are important tools and methods to improve the ability of NPO analysis. The widespread application of artificial intelligence is the general trend, but in order to use artificial intelligence more safely, it is necessary to continuously strengthen data protection legislation and strengthen user privacy protection in artificial intelligence applications. It is forbidden to obtain data at the expense of user privacy. NPO is a multidisciplinary research field, covering a wide range of fields including computer science, political science, management, information technology, and social sciences.

Table 3. The top 10 subject categories in NPO studies, 1990–2020.

Rank	Quantity	Centrality	WOS Categories	Percent/%
1	455	0.41	Computer Science	32.85
2	271	0.24	Engineering	19.57
3	222	0.51	Computer Science, Information Systems	16.03
4	210	0.32	Computer Science, Theory and Methods	15.16
5	188	0.16	Communication	13.57
6	186	0.31	Engineering, Electrical and Electronic	13.43
7	135	0	Government and Law	9.75
8	126	0.04	Political Science	9.10
9	126	0.24	Computer Science, Artificial Intelligence	9.10
10	78	0.17	Telecommunications	5.63

3.2.3. Institute Distribution of Literature

According to the WOS core database, a total of 1309 institutions published literature, and the records of some publishing institutions that were no longer associated with the subject were manually removed. The remaining 73 institutions had collaborative relationships. The 10 institutions with the most relevant papers published are shown in Table 4. China and the United States are the major contributors in this area. Among these 10 institutions, the Chinese Academy of Sciences (36) published the most thesis papers, Beijing University of Posts and Telecommunications (23) and Huazhong University of Science and Technology (18); the institutions with the highest average citations are the University of Michigan (US, 46.64), University of Wisconsin (US, 29.79) and Ohio State Univ (US, 28.36). Although the Chinese Academy of Sciences has published the most papers, the ACI is only 5.97.

Table 4. The top 10 institutions in NPO studies, 1990–2020.

Rank	Institution	Country	Quantity	Total Link Strength	STC	ACI
1	Chinese Acad Sci	China	36	30	215	5.97
2	Beijing Univ Posts and Telecommun	China	23	6	27	1.17
3	Huazhong Univ Sci and Technol	China	18	2	84	4.67
4	Univ Chinese Acad Sci	China	18	23	129	7.17
5	Beijing Jiaotong Univ	China	16	6	71	4.44
6	Natl Univ Def Technol	China	15	5	15	1
7	Ohio State Univ	Europe	14	6	397	28.36
8	Univ Michigan	USA	14	8	653	46.64
9	Univ Wisconsin	USA	14	10	417	29.79
10	Harvard Univ	USA	13	6	346	26.62

STC: Sum of the Times Cited. ACI: Average Citations per Item.

The Chinese Academy of Sciences has a wide range of research directions: Ma and Liu [35] believe that online opinion leaders are very important figures in the network community and play an important role in promoting the formation of public opinion. An opinion leader recognition algorithm based on super network theory is proposed. This algorithm combines network topology analysis and text mining, researches and establishes a super network model that includes social, psychological, environmental, viewpoints and other multi-dimensional sub-networks. On this basis, four super network indexes are proposed: node super degree, super edge degree, super edge-super edge distance and super edge overlap. Jiang et al. [36] found that existing sentiment calculation methods are mainly based on standard sentiment thesaurus or supervised methods, cannot be extended to social media big data. They proposed a novel method for calculating emotions in news events. Based on the social media data of news events, a word emotion association network is constructed, its semantics and emotions are jointly expressed, which lays the foundation for the emotion calculation of news events. The experimental results on real data sets show that this method has good performance for sentiment calculation of news

events. Wang et al. [37] established an NPO super network model based on the coupling mechanism of NPO events, proposed a hyper-edge coupling algorithm based on the law of gravity. Lian et al. [38] developed a model for describing the topological structure of NPO, which has better accuracy in describing the distribution of NPO, which will help future research in this field.

VOSviewer was utilized to filter the institutions with publication volume no less than 8 and 73 institutional records were obtained, irrelevant institutional records were manually deleted to generate the cooperation network graph of major research institutions (see Figure 6). The size of the nodes in the graph represents the high volume of their published literature, the width of the connecting line between the nodes represents the intensity of their cooperation, which shows that the most frequent cooperation between Chinese Academy of Sciences and the University of Chinese Academy of Sciences. The clustering analysis of VOSviewer divided the 63 institutions into 11 clusters, and the red clusters (Tsinghua University, etc.) dominated the inter-institutional cooperation, followed by the University of Michigan University and the University of Wisconsin as the dominant green clusters. Finally, blue clusters (CAS, BUPT, etc.) dominate, with CAS containing the largest number of papers, the highest total connection strength of nodes in this cluster, and a wide range of research directions. Among them, the Chinese Academy of Sciences contains the largest number of papers. The total connection strength of the nodes in this cluster is the highest, and the research direction is wide.

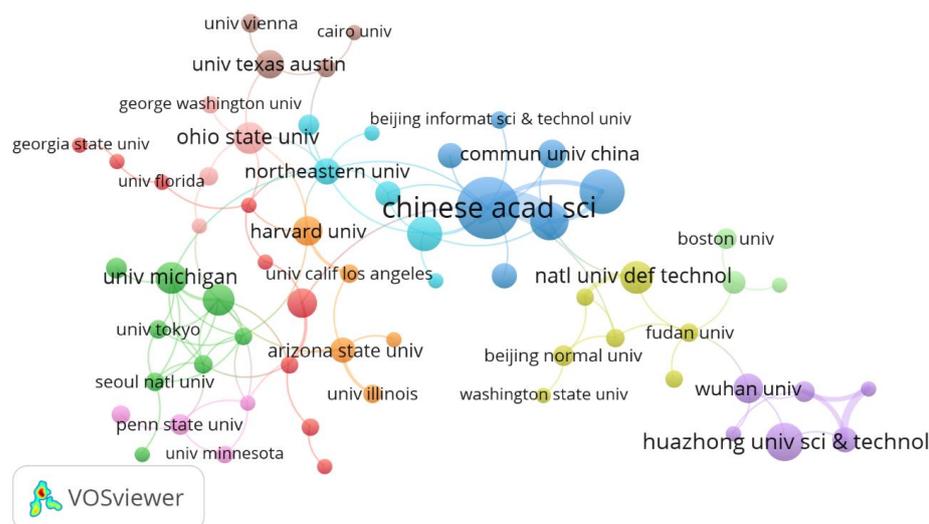


Figure 6. Cooperation institutions in NPO studies, 1990–2020.

3.2.4. Journal Distribution

We analyzed the distribution of major source journals in the field of online opinion research by using VOSviewer and obtained 33 records after filtering. The network diagram of major journals was outputted as shown in Figure 7. In the network diagram, each node represents a journal, and the larger the node is, the greater the number of published papers. Available *IEEE Access*, *International Journal of Communication* and *Physica A-statistical Mechanics and Its Applications* rank among the top three. In the seven clusters, red and green are the mainstays. The largest node in the red cluster is physical-statistical mechanics and its applications. The size of the nodes in the green cluster is relatively even. Green clustering is mainly based on computer science and social science, and uses the principles of other disciplines to conduct research in a certain field, such as *Communication Research*, *Social Science Computer Review* and *Public Opinion Quarterly*; the red cluster is supplemented by journals related to international environment and statistics; the blue cluster is mainly composed of journals on social media and information.

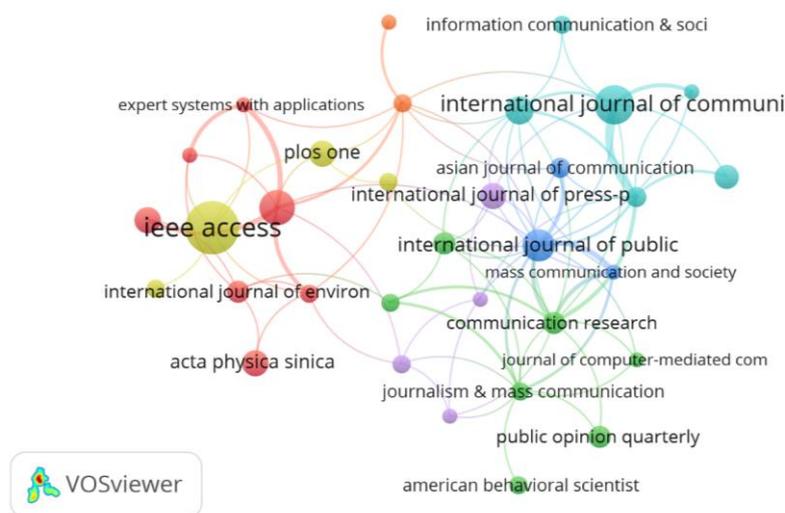


Figure 7. Cooperation of main research journals in NPO studies.

3.3. High-Cited Literature ANALYSIS

Table 5 lists the titles, authors, journals, years, average annual citations (ACY), number of institutions (IN) and countries (CN) of the literature. The most frequently cited paper of Fraser [39] focuses on public opinion in the transnational public sphere, in order to make it more normative and politically effective. Shaw and Gant [40] suggested that with the increasing popularity of the Internet and the growing number of users using it, it is important to pay more attention on the mental health of Internet users. Esrock and Leichy [41] wanted to find out if brick-and-mortar companies would use online opinion to promote their culture to the public, which turned out not to be the case. Huckfeldt et al. [28] have studied a theory of political communication that suggests that groups with strong opinion cohesion are more conducive to the spread of public opinion, it is believed that the construction of civil society networks acts as a filter for the macro environment of political information. Ceron et al. [42] studied the application of NPO in the political sphere. The findings indicated that social media has the ability to predict election outcomes and that there is a correlation between social media and the results of popular surveys. When the number of citizens expressing their opinions online increases, the predictive power of social media analysis also increases. Lee and Jang [43] examined how readers’ reactions to news on the website included whether it influenced personal opinions and evaluations of social media influence.

In terms of the publication time of highly cited literature [48,49], 5 articles were located in the beginning stage, 8 articles in the stable growth stage and 2 articles in the rapid development stage.

Table 5. The top 10 papers with the most citations, 1990–2020.

Rank	STC	Title	Authors	Journal	Year	IN	CN
1	309	Transnationalizing the public sphere—On the legitimacy and efficacy of public opinion in a post-Westphalian world	Fraser [39]	Theory Culture and Society	2007	1	1
2	302	In Defense of the internet: The relationship between Internet communication and depression, loneliness, self-esteem, and perceived social support	Shaw and Gant [40]	Journal of Communication	2002	2	1

Table 5. Cont.

Rank	STC	Title	Authors	Journal	Year	IN	CN
3	297	News coverage of the gulf crisis and public-opinion-a study of agenda-setting, priming, and framing	Iyengar and Simon [27]	Communication Research	1993	2	1
4	276	Social responsibility and corporate web pages: Self-presentation or agenda-setting?	Esrock and Leichty [41]	Public Relations Review	1998	2	1
5	216	Political, environment, cohesive social-groups, and the communication of public-opinion	Huckfeldt [28]	American Journal of Political Science	1995	4	1
6	192	Every tweet counts? How sentiment analysis of social media can improve our knowledge of citizens political preferences with an application to Italy and France	Ceron [42]	New Media and Society	2014	4	1
7	184	Analyzing the representativeness of internet political participation	Best and Krueger [44]	Political Behavior	2005	2	1
8	177	Exploring the nature of the best:International relations theory and comparative policy analysis meet the European Union	RisseKappen [45]	Journal of Common Market Studies	1996	3	1
9	144	Social-psychological influences on opinion expression in face-to-face and computer-mediated communication	Shirley and Douglas [46]	Communication Research	2008	2	1
10	141	Assessing the democratic debate: How the news media frame elite policy discourse	Callaghan and Schnell [47]	Political Communication	2001	1	1

3.4. Co-Authorship Analysis

A collaborative network of highly productive authors was generated by automatically forming seven clusters after using VOSviewer (see Figure 8), where the node size represents the number of authors’ publications, the connecting lines between different nodes represent the collaboration between authors, and the width of the connections represents the strength of the collaboration. It can be seen that the top three authors in terms of number of articles are Yijun Liu (55 articles), Lingyu Xu (40 articles) and Gaowei Zhang (40 articles).

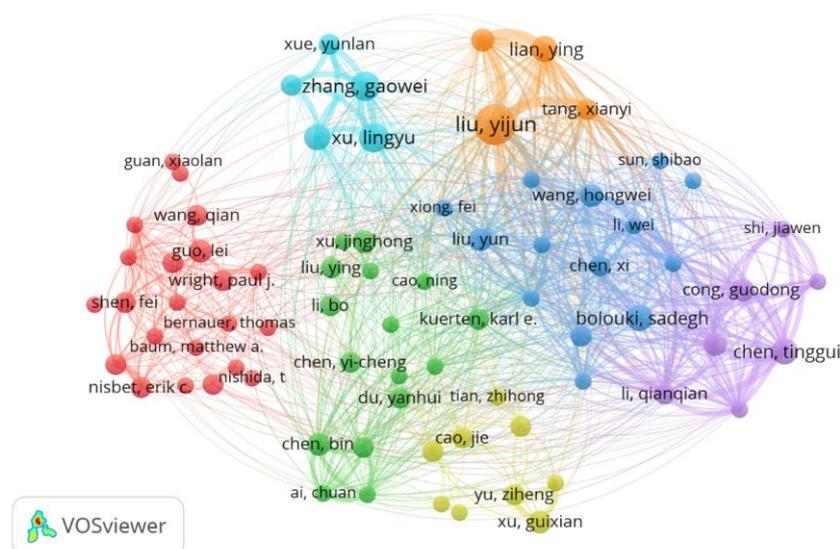


Figure 8. Cooperation authors in NPO studies.

The top 10 most published authors are shown in Table 6, of which 9 are from China, with Yijun Liu publishing the most articles with an average citation rate of 10.08. There are collaborations with many well-known institutions such as the Chinese Academy of Sciences, Beijing University of Posts and Telecommunications, the University of Michigan, and the University of Wisconsin. The remaining two are Lingyu Xu and Gaowei Zhang both from China.

Table 6. Top 10 authors in NPO studies, 1990–2020.

Rank	Author	Organization	Country	Links	Quantities	ACI
1	Liu, Yijun	University of Insubria	China	55	12	10.08
2	Xu, Lingyu	United Technologies Corporation	China	40	7	1.71
3	Zhang, Gaowei	Jiaxing University	China	40	7	1.71
4	Bolouki, Sadegh	European Commission Joint Research Centre	Netherlands	23	6	1.83
5	Chen, Tinggui	Yokohama National University	China	47	6	9.33
6	Lian, Ying	Yokohama National University	China	42	6	3.67
7	Wang, Lei	Japan Automobile Res Inst	China	39	6	0.5
8	Chen, Bin	Lawrence Livermore National Laboratory	China	37	5	7.8
9	Cong, Guodong	European Commission Joint Research Centre	China	47	5	10.2
10	Dong, Xuefan	European Commission Joint Research Centre	China	37	5	3

ACI: Average Citations per Item.

3.5. Research Knowledge Base

H.G. Small, an American intelligence scientist, introduced the concept of co-citation analysis in 1974. He pointed out that the structure and characteristics of the discipline and the literature represented by the research object can be analyzed by studying the co-citation relationship between the literature, which means that if two papers appear together in the reference list of the third cited paper, the two papers form a co-citation relationship [50]. Our analysis of co-cited literature is to study the knowledge base of the field, then the journals that carry the co-cited literature are the carriers of the knowledge base, and the high co-cited journals also represent the core journals that are at the forefront of research in the field. We used CiteSpace and VOSviewer to conduct literature co-citation analysis and journal co-citation analysis, respectively. By analyzing the co-cited literature and its sources, we can identify the knowledge base and core journals in the field of NPO research. In addition, co-citation analysis can complement the traditional literature review by identifying the most active areas and filling the research gaps in the field [51]. Some scholars have studied the field of sports industry and public procurement using co-citation analysis, and some of the analytical methods and theoretical knowledge are worth learning [52].

The design of CiteSpace is mainly based on Kuhn's theory of scientific development model, Price's theory of scientific frontier and theory of discrete and reorganization of knowledge units, etc. With the support of these strong theoretical foundations can enhance the interpretability, the rationality and the correctness of the interpretation of the map.

3.5.1. The Reference Co-Citation Analysis

If two references are cited at the same time, it means that they are somewhat related to each other, and if they are cited more often at the same time it means that they are more related [53], then the most cited reference can be considered as the knowledge base of a subject area to some extent.

We analyzed the literature co-citations by using the co-citation analysis function of CiteSpace. Literature co-citation analysis is used to quantify the academic influence of literature in the field based on two indicators: node size and the level of mediated centrality. The larger the nodes indicate the higher frequency of co-citation, and the closer the nodes are to each other, the stronger the co-citation relationship. From Figure 9, we can see that the color of the nodes and the connecting lines gradually change from green to yellow from left to right, indicating that the time from left to right is increasing. Therefore, most of the nodes on the left side are cited literature from earlier years, while most of the nodes on the right side are from recent years.

Larger nodes indicate higher citation frequency, and according to Figure 9 it can be seen that the author with the highest citation frequency is Ferrara E, it means that the top ranked item by citation counts is Ferrara E (2016), with citation counts of 13. The second one is Liu YJ (2014), with citation counts of 11. The third is Ma N (2014), with citation counts of 11. The 4th is Bakshy E (2015), with citation counts of 10. The 5th is King G (2013),

with citation counts of 10. By comparing centrality, we found that the top ranked item by centrality is Bakshy E (2015), with centrality of 0.33. The second one is Boulianne S (2015), with centrality of 0.25. The third is Parsegov SE (2017) in, with centrality of 0.20. The 4th is Allcott H (2017), with centrality of 0.19. The 5th is King G (2013), with centrality of 0.11.

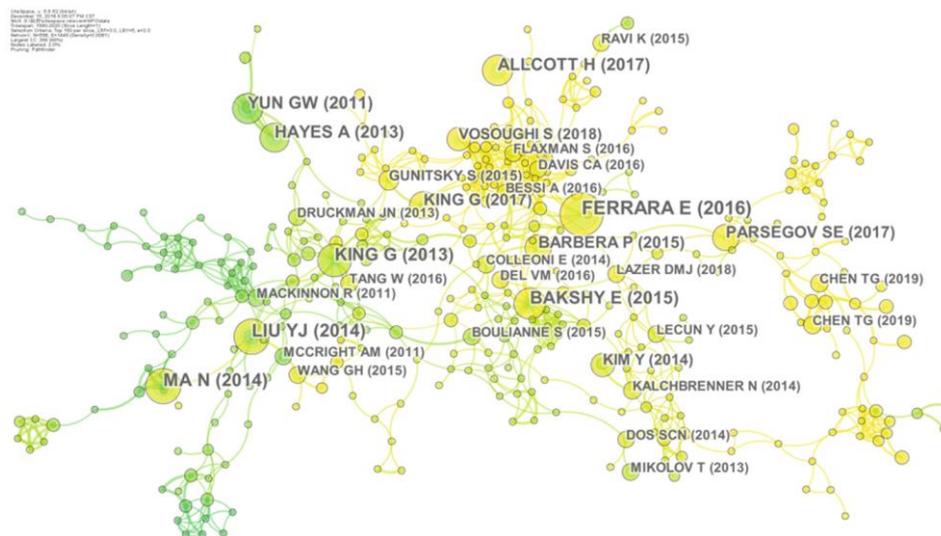


Figure 9. Authorship analysis of references in NPO studies.

By comparing the number of citations and centrality we found that the authors Bakshy E, King G and Allcott H have the highest number of citations and centrality, indicating that their published articles are representative of the core literature in the field of NPO. The authors of Bakshy E pointed out how the internet influences people's opinions in the face of ideologically diverse information with the widespread use of social media [54]. The other two authors focus more on the spread of public opinion, especially the spread of disinformation on the Internet. Taking the 2016 U.S. presidential election as an example, how disinformation was spread and what consequences it led to. How to regulate disinformation published on the Internet in the future is a question worthy of scholars' consideration [55,56].

The network is divided into 9 co-citation clusters. These clusters are labeled by index terms from their own citers (Figure 10). The top one is Cluster #0, with centrality of 0.25. The second is Cluster #7 with centrality of 0.20. The 3th is Cluster #8, with centrality of 0.19. The 4th is Cluster #2, with centrality of 0.10. The 8th is Cluster #3, with centrality of 0.09. The 5th is Guess A (2019) in Cluster #1, with centrality of 0.08 according to centrality. Therefore, #0 is a high centrality cluster, indicating that this cluster is highly influential in the field of NPO research. In addition to the top ranked item by bursts is Cluster #0, with bursts of 4.33. The second one is Cluster #7, with bursts of 4.06. The third is Cluster #2, with bursts of 3.85.

Cluster #0 is focused on media audience. Gamson and Modigliani [57] discussed the relationship between media discourse and the construction of two parallel systemic meanings of public opinion by analyzing four kinds of general audience media. Chong and Druckman [58] examined the mental model of how framing affects public opinion. The research of Iyengar et al. [59] shows that the further proliferation of new media and the increase of media choices may lead to further differentiation of news audiences. Other scholars [60,61] have examined how social media affects public opinion in the political sphere, and have pointed out the limitations of public opinion in the digital age. In addition, social media content analysis is used to continuously monitor public opinion in order to keep it in a healthy environment [62].

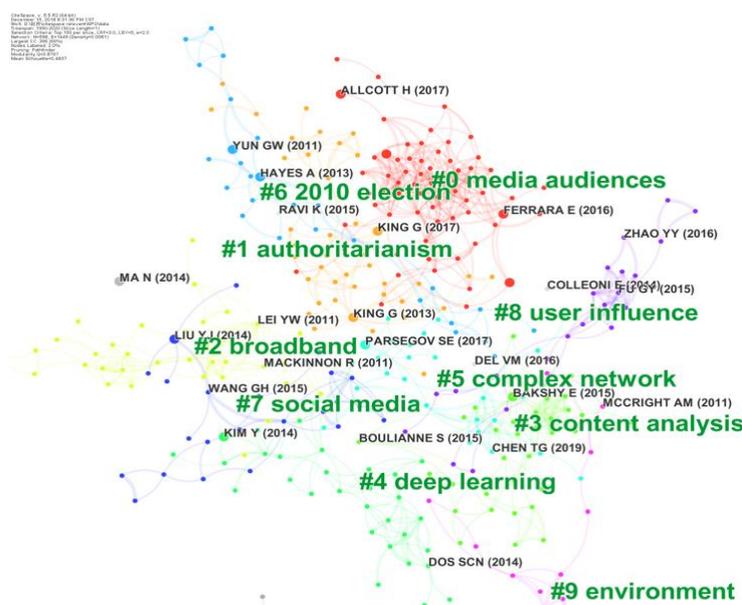


Figure 10. The reference co-citation analysis in NPO studies.

Cluster #7 deals with social media. Many scholars have proposed new theories and models to make improvements to social media in an effort to build a healthy and safe online ecosystem. Deffuant et al. [63] provided a model of opinion dynamics. High thresholds lead to a convergence of opinions to average opinions while low thresholds lead to several clusters of opinions. The study shows that members of the same cluster have the same opinion but are no longer influenced by members of other clusters. Ma and Liu [35] proposed a SuperedgeRank opinion leader recognition algorithm based on super network theory, by which opinion leaders can be evaluated and identified. Sznajd-Weron and Sznajd [64] proposed the Ising spin model, which can describe the mechanisms of decision making in closed communities. Some scholars have also studied the evolution of public opinion on social media, and by modeling the evolution of online opinion can promote social harmony [65]. The study of the spiral of silence theory allows the dissemination of NPO to develop toward a good posture [66]. Wang et al. [67] proposed social media as a vehicle to study the factors influencing the spread of public opinion in terms of information sources, information content, and communication channels. In addition, Li et al. [68] and his team concluded the study indicates that social media can promote public affairs communication and civic responsibility.

In Cluster #8, the subjects of user influence related to opinion dynamic modeling and sentiment analysis. By studying the dynamic model of opinions with different algorithms, scholars hope to build a more realistic dynamic model in order to better collect individuals' opinions and facilitate the dissemination of public opinion [69,70]. Other scholars have compared learning models such as Vector Machines (SVM), Naive Bayes (NB) and Artificial Neural Networks (ANN) to make it more accurate when performing sentiment analysis [71]. Jiang and Chen studied [72] the emotional characteristics and the evolution of public opinion over time based on the emotional characteristic words of online opinion participants, to effectively analyze the emotional characteristics of online opinion participants.

Through the analysis of literature co-citations, we summarized the cited references from 1990 to 2020 and sorted them out. We filtered the references according to the number of citations, centrality and burst and the final results are shown in Figure 11. The sorted representative literature are the articles with high citation counts and high centrality in that year. This also means that that year is a representative article in the field of NPO research, which can be considered as the knowledge base of the subject area to some extent.

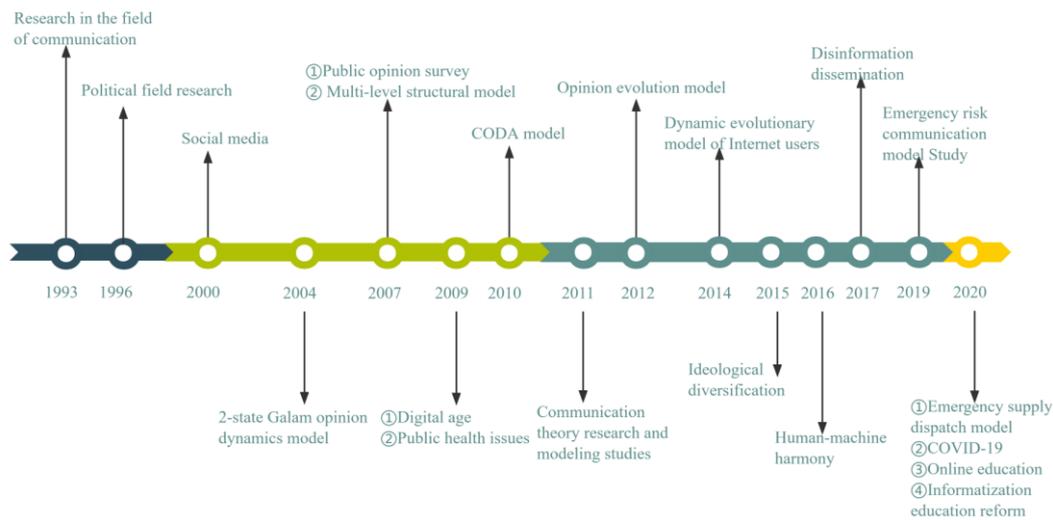


Figure 11. The main active areas of NPO research.

In the 1990s, scholars studied how to make NPO better suited to the communication and political fields, and after 2000, the direction of scholars' research became to continuously propose new theories and build new models to make NPO more suitable for a variety of fields [73,74]. When an emergency public health event occurs, if we cannot correctly grasp the law of the dynamic evolution of public opinion on the Internet and control and guide it, the spread of public opinion on the Internet will have a negative impact on social harmony and stability. In the following years, the development of NPO is more inclined to consider human feelings, such as "human-computer harmony", "emotional analysis", etc. [75,76]. Focusing on the dissemination of public opinion and the release of social media disinformation is also another research hotspot [55,77]. In recent years, public health events have been frequent, and the study of emergency risk propagation models and emergency supply dispatch models is also a topic of research for many scholars [75,78].

3.5.2. The Journal Co-Citation Analysis

Co-citation analysis of journals can be used to locate and classify journals, and to determine their core or marginal position in the discipline, thus enabling a more objective evaluation of academic journals. The co-citation network map of journals drawn by using VOSviewer with the category of "Co-citation" and the node type of "Cited sources" was filtered to obtain a co-citation network map of 57 nodes (see Figure 12). The distance between nodes represents the relationship between journals, and the closer the distance, the stronger the co-citation relationship of journals. The 57 journals are divided into four clusters, dominated by the red, green, blue and yellow clusters, with four main types of research: physical applications, social sciences, information communication and social media. The red cluster includes *Physica A-Statistical Mechanics and Its Applications* (427 citations), *Physical Review E* (332 citations), which are mainly journals on physics applications, physical reviews; the green cluster includes *Public Opinion Quarterly* (485 citations), *American Political Science Review* (435 citations), which are mainly interdisciplinary, social science journals; the blue cluster includes *Journal of Communication* (652 citations), *Communication Research* (397 citations), and *Political Communication* (320 citations), which are mainly journals on political communication and information exchange. The yellow cluster includes *New Media & Society* (220 citations) and *NY Times* (150 citations), which are mainly journals on social media. The most cited journals are: *Physica A-Statistical Mechanics and Its Applications*, *Public Opinion Quarterly*, *Journal of Communication*, and *New Media & Society* as the most core journals in different research directions.

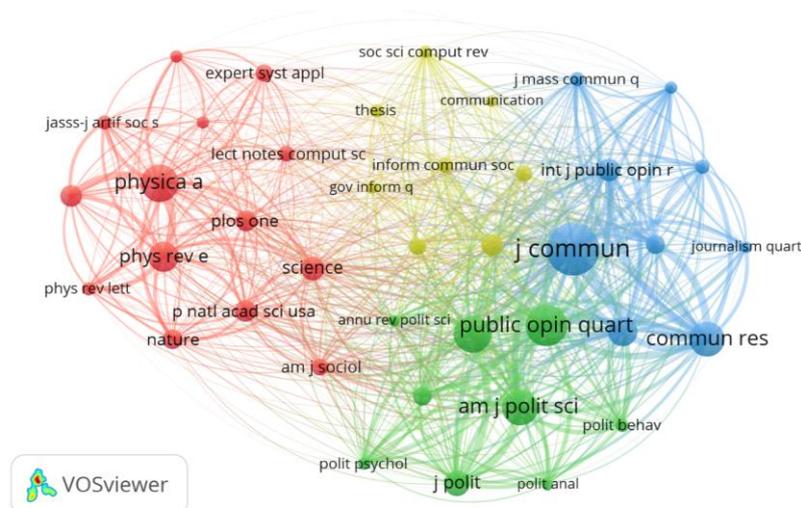


Figure 12. The journal co-citation network of NPO studies.

3.6. Research Hotspots and Frontier Analysis

3.6.1. Research Hotspot Analysis

Keyword analysis can be used to identify the frontiers of research in the field and it can also reflect the core content of the article [79]. A total of 4782 keywords were analyzed by VOSviewer, keywords with a frequency of not less than 8 occurrences were selected and checked article by article, 155 keywords were obtained after appropriate editing. We extracted the 20 most frequent keywords as shown in Table 7, “public opinion” occupies an absolute position, and public opinion is the basis of NPO, without which no NPO can be created. NPO is the development and extension of public opinion, which elevates traditional public opinion to the network as the carrier and focuses on expressing attitudes, opinions and views in the network; “internet” is an important means to realize NPO, which is the essential difference between traditional public opinion and NPO, and breaks the limitation of traditional public opinion in time and space with the help of internet, greatly improves the speed and efficiency of NPO; “internet” is the important means to realize NPO. The Internet breaks the limitations of traditional public opinion in time and space and greatly improves the speed and efficiency of NPO; “social media” is an important means to realize the freedom of NPO, and all Internet users can fully express their opinions through social media such as BBS, microblogs, forums, blogs and news reviews, etc. Due to the anonymity of social media, most Internet users will express their true opinions. Most Internet users will express their true opinions. “Information”: there are two types of information about NPO: correct and incorrect. The supervisory department needs to disseminate correct information to every Internet users to ensure that the information they see is true, while false, rumor and other incorrect information needs to be strengthened, especially government departments need to correct the distorted public opinion with correct information to influence the public. In most cases, people have a tendency to listen to rumors and follow the herd because they do not receive valid authoritative information from the government. Therefore, to influence the public with true, effective and high-quality information and to guide public opinion is the top priority at present and even in the future; “communication” is the stage of communication where public opinion is most likely to be biased. If the way of information dissemination or the way and method of communication are not correct, public opinion will be biased.

In the keyword co-occurrence network view, the thinner the link between nodes, the less the number of co-occurrences between keywords, and vice versa. A total of four clusters are generated as shown in Figure 13. The total link strength between nodes is 5642 and the link is 2882. the development of online opinion (red) and opinion-based research (green) dominate.

for online opinion dissemination. Yang [84] illustrated that the main methods of online opinion analysis at this stage include data collection, spam extraction, similarity clustering and sentiment analysis. The traditional TF-IDF method is proposed to be improved by introducing partial speech weight coefficients and position weights of feature words. He et al. [85] took the 2017 Hunan flood in China as an example based on the data source of Sina Weibo and combined with text analysis and image analysis techniques to define the scope of natural disasters. The sentiment analysis method and correlation analysis method were used to find out the patterns of the development and changes of NPO, to provide opinions and suggestions for the identification of disaster areas, disaster relief and control of NPO.

Technical means of online opinion (red): the red clusters represent the technical means of online opinion, with “model”, “social network”, “machine learning” and “sentiment analysis” as the main ones. Fang et al. [86] proposed the traditional rules of using individual populist tendencies to increase the threshold of opinion differences and optimize individual opinion interactions. Zhang and He [87] introduced a dynamic model based on the SIR model and complex networks by modifying the Weisbuch-Deffuant model to analyze the diffusion of NPO. Li et al. [88] analyzed the impact of NPO using a hybrid research strategy of natural language processing and convolutional neural networks. Xu et al. [89] proposed that a weighted LDA model can effectively improve the quantity and quality of sensitive information recognition. The results of the study show that this model can help to the development of artificial intelligence. Liu et al. [85] pointed out that as the influence of NPO on the community continues to expand, the use of engineering techniques becomes a key technology for analyzing and dealing with NPO. The key techniques of text clustering were studied, and a technique of detecting public opinion topics based on hierarchical clustering was introduced. The technique improves the traditional hierarchical clustering algorithm for NPO. It can distinguish opinion topics at different levels and obtain results with different granularity. Zhang et al. [90] proposed a detection method based on current web events based on the principles of rumor propagation, sentiment analysis of texts and the characteristics of NPO.

Challenges to NPO (yellow): The main focus is on “media”, “news”, “power” and “exposure”. First of all, NPO brings us information, so that Internet users can express his or her opinions and speeches anytime and anywhere. With the increasing popularity of the Internet, many water forces on the network, driven by interests, spread rumors and false information on the Internet, seriously disrupting the normal order of the network and affecting the social harmony and stability. Therefore, a large amount of information and speeches will become a bad force affecting social stability if not regulated in place, so it is said that NPO is a double-edged sword. It is the government’s responsibility to prevent and deal with public opinion crises, it should follow the basic principles of taking responsibility, timely communication, information disclosure and guiding public opinion. The government’s response to public opinion crisis cannot be solved by some measures alone but requires the improvement of the whole social environment. In order to deal with public opinion crisis, the government must strengthen its own construction, properly deal with social crisis and ensure the harmony and stability of society. However, with the maturity of public opinion analysis methods, it is difficult to make a breakthrough in lexicon-based analysis methods, it is hard for lexicons to be replenished at the speed of online language evolution. However, machine learning methods do not improve the accuracy of models due to the lack of large amounts of labeled data, and research indicates that the focus of current research in opinion analysis has shifted to real-time learning [13]. Xu et al. [91] considered sentiment analysis techniques as part of artificial intelligence, so he proposed to integrate sentiment information in the TF-IDF algorithm, and this study is important for obtaining sentiment trends of reviews. NPO can reflect people’s socio-political attitudes, so it is important to study the trend prediction and evaluation methods of NPO for managers’ decision making. Furthermore, through the analysis of NPO topics,

the evaluation system and evaluation scheme of NPO topics are proposed, and the early warning system is also a new idea for the healthy development of NPO in the future.

3.6.2. Research Frontier Identification

We conducted a keyword co-occurrence analysis by using CiteSpace and generated a keyword timeline graph (see Figure 14). As shown in the figure, the horizontal axis represents time, the nodes represent keywords, the “circle” node represents the high frequency of that keyword, the line between the nodes represents the co-occurrence relationship between the keywords, and the larger the “circle” is, the higher the frequency of that keyword. When the frequency of a keyword suddenly changes it turns into a red node, which also represents the emergence of a new research trend. Nodes with purple outer circles indicate that their centrality is no less than 0.1, indicating that this keyword is the hub that connects other keywords. The three keywords with the highest centrality are “management” (0.4), “news” (0.38), and “science” (0.37). In the initial development stage (1990–2001), the research directions were fewer and mainly focused on “public opinion” and “Internet”. After entering the stable development stage (2005–2012), research directions expanded and research hotspots shifted to “media”, “social networks”, “communication” and “models”. Re-research hotspots in the rapid development phase (2013–2020) include “social media” (model), “sentiment analysis” and “big data”. Currently, the use of opinion analysis methods to explore the sentiment of user comments has become one of the popular research topics and has been applied in many business and public administration fields. Scholars closely link NPO with computer science, big data, models and algorithms, using computer science, natural science and engineering principles as means to conduct NPO research, and apply scientific and technological means to make NPO develop in a more diversified direction.

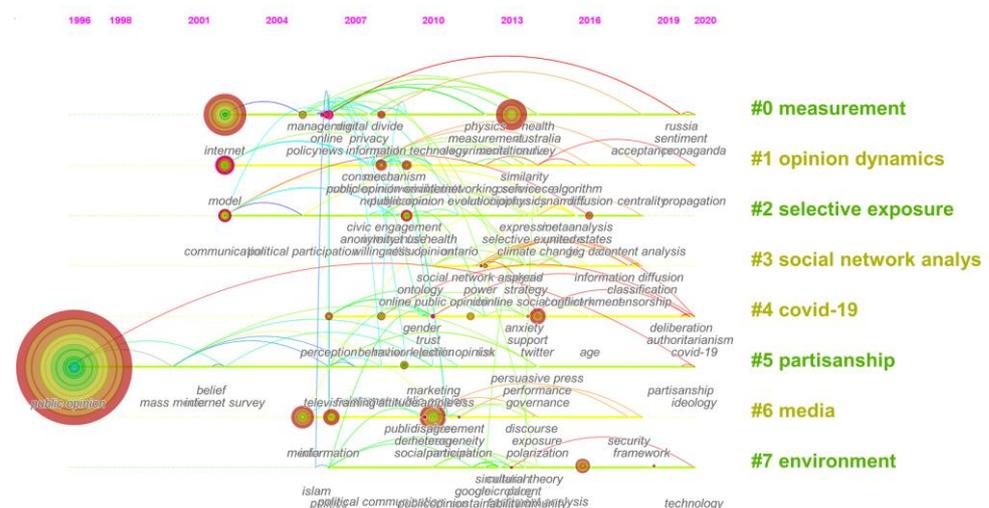


Figure 14. The keywords timeline view of NPO studies.

As shown in Figure 14, COVID-19 has become a new keyword. Due to the sudden outbreak of COVID-19, which posed a great challenge and threat to public health in our country and the whole world, there was an ensuing lively discussion of information about COVID-19 on social media. Social media platforms can be used to measure the level of public concern about public health emergencies. Studies have indicated that public hotspots about the COVID-19 outbreak can be learned on social media, these findings can help governments and health departments to better communicate public health issues with the public, and in turn, translate public health needs into practice and develop targeted measures to prevent and control the spread of the COVID-19 [34]. Preventing and controlling the epidemic spread of infectious diseases requires public participation, so it is extremely important to know what the public knows about COVID-19 during an outbreak.

This knowledge is important to help them learn how to respond to outbreaks of infectious diseases such as COVID-19 [92].

With the rapid growth of social media in recent years, more and more public health departments and individuals are willing to use social media to share information and communicate with others when public health emergencies occur. To some extent it can be considered that social media is likely to be an important tool to facilitate risk communication during special periods [93]. Social media can help public health departments to better prevent and control the outbreak by keeping track of public attitudes toward NCCP. The consultation service is free. Doctors are available 24 h a day to answer questions online for free, helping the public to make preliminary judgments about the disease and avoiding blind medical consultations caused by panic. In addition, “Good Doctor” has also summarized the FAQs of NCCP to let the public know more about the epidemic.

The 12 keywords with the highest burst intensity, along with its start time, end time and intensity, were derived using the Burst Detection function in CiteSpace (see Table 8). “internet” (7.0708) has the highest burst intensity, followed by “sentiment analysis” (6.7675) and “public opinion” (6.324). The reason for the earliest start of the burst of “public opinion” and its duration of 9 years is the importance of the influence of public opinion on society. The sum of NPO is not only a mapping of public opinion in the web, but also a direct response to social public opinion [94]. The temporal consistency of “web”, “selective exposure” and “big data” bursts. In order to understand the spatial and temporal evolution of NPO and reveal its formation mechanism, we investigated several popular online commentary data using statistical physics methods. The empirical results show that NPO concerns are heterogeneous in different areas and follow the double power law, but there is an obvious consistency in the evolution of NPO concerns. Through correlation analysis, we found that regional population and economy may have significant effects on event attention and the consistency of attention in different regions stems from the strong correlation between regions. On the other hand, public opinion guidance can significantly influence attention to events, leading to a rapid increase in the speed of propagation. By calculating the information entropy of propagation speed, we concluded that the geographical distribution of online comments is relatively stable most of the time, and opinion guidance may help maintain this consistency. In addition, “big data”, “machine learning”, “deep learning”, the “centrality” and “sentiment analysis” are in a state of burst and are at the forefront of NPO research.

Table 8. Top 12 Keywords with the Strongest Citation Bursts, 1990–2020.

Keywords	Strength	Begin	End	1990–2020
public opinion	6.324	1996	2005	-----
internet	7.0708	2002	2007	-----
television	3.7893	2006	2011	-----
web	3.8174	2006	2009	-----
internet public opinion	6.2529	2009	2013	-----
selective exposure	3.739	2014	2017	-----
NPO	4.7567	2015	2017	-----
big data	4.703	2017	2020	-----
machine learning	3.8496	2018	2020	-----
deep learning	4.4979	2018	2020	-----
centrality	3.5947	2018	2020	-----
sentiment analysis	3.5003	2018	2020	-----

The Timezone function of CiteSpace was used to calculate and organize the keyword time zone map of Internet opinion security research, specifically shown in Figure 15. Due to the short development time of Internet opinion in this province, it can be seen that no hot keywords were generated before 1996, and by the end of the initial development period in 2002, these hot keywords are “public opinion” and “internet”. With the continuous improvement of science and technology, the development of NPO entered into a stable

development period in 2005, and the research hotspots include “media”, “perception”, “management”, “policy” and “online”. Then in 2008, the research entered a rapid development phase, and many hot keywords emerged, such as “opinion”, “sentiment analysis”, “dynamics” and “public sphere”, etc.

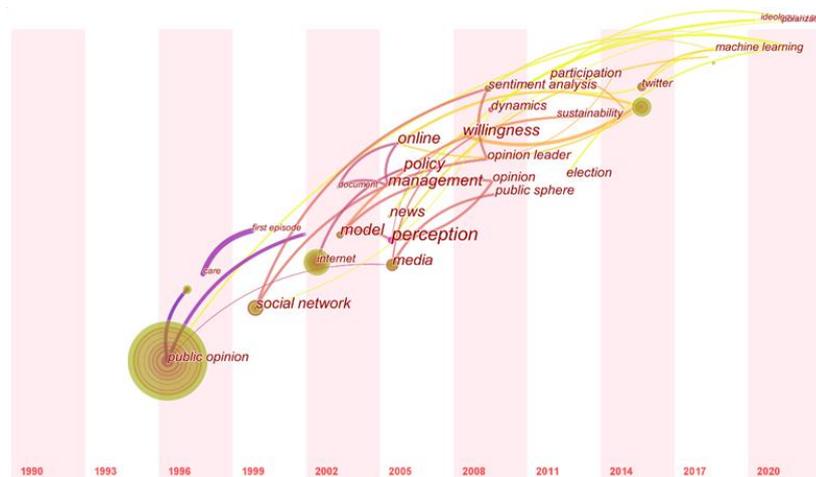


Figure 15. The keywords TimeZone view of NPO studies,1990–2020.

The keyword time zone diagram can show the knowledge evolution of hotspots in NPO research from the time dimension; the nodes in the diagram indicate the keywords in the corresponding years and the connecting lines between the nodes indicate the inheritance relationships among the keywords. Based on the linking relationships in the diagram, the changes of research hotspots in this research area and the connections among hotspots are clearly illustrated. From the figure, it can be seen that early NPO was mainly studied in the initial stage and with the increasing popularity of the Internet scholars began to focus on NPO. After 2005, social media, policy, news, management and network became hot spots for research. With the advent of big data era, big data technology and application have become a hot topic in academia. It shows that NPO is a topic worthy of research and full of promise in the future.

4. Conclusions and Future Work

Information visualization software was used to conduct a bibliometric analysis of the literature related to NPO in SCIE, SSCI, A&HCI and CPCI-S from 1990 to 2020 in this paper, which focuses on the spatial and temporal distribution of literature output, core literature, author contributions, research knowledge base and analysis of research hotspots and frontiers. Three types of knowledge bases in the field are identified by mapping the co-citation network of NPO literature. The keyword co-occurrence analysis was used to identify the research hotspots in each period, and then to identify the current research frontiers of NPO. The main conclusions were obtained as follows.

- (1) The development history of the field of NPO is roughly divided into three phases: the initial phase (1990–2006), the rapid development phase (2007–2013) and the stable growth phase (2014–2020). In terms of the distribution of articles by country, the United States and China topped the list, indicating that these countries are the development centers and active regions of NPO. In terms of research institutions, the Chinese Academy of Sciences, Beijing University of Posts and Telecommunications and Huazhong University of Science and Technology have the most scientific achievements. In terms of disciplinary distribution, NPO is based on “computer science,” “engineering,” “information systems” and “theoretical methods. The distribution of internet opinion is based on “computer science”, “engineering”, “information system” and “theory and methodology”. “Communication”, “Engineering, Electrical and Electronics”, “Government and Law” and “Political Science” are the external

environment that ensures the healthy development of NPO. The external environment for the healthy development of public opinion. “Artificial intelligence”, “telecommunications”, and “interdisciplinary applications” are important tools and methods for improving online opinion analysis. *IEEE Access*, *International Journal of Communication* and *Physica A-statistical Mechanics and Its Applications* are the main carriers of literature in this research area.

- (2) The knowledge base in the field of NPO research includes social media, user influence, and user influence related to opinion dynamic modeling and sentiment analysis. The vectors of co-cited literature can be roughly divided into four categories: social and computer sciences, statistics, social media, and information. In addition, the core journals in this field are *IEEE Access*, *International Journal of Communication*, *Physica A-statistical Mechanics and Its Applications*, and *International Journal of Public Opinion Research*. It was found that the authors of the five articles with the highest co-citation frequency (Fraser, 2007; Shaw and Gant, 2002; Iyengar and Simon, 1993; Esrock and Leichty, 1998; Huckfeldt, 1995) are experts who have made outstanding contributions to the field of network opinion research.
- (3) There are four hot spots in the study of NPO: analysis of public opinion, analysis of NPO dissemination channels, technical means of NPO, and challenges of NPO. By using CiteSpace’s keyword time zone diagram, we found that there were no hot keywords generated before 1996, and the hot keywords “public opinion” and “internet” appeared in 2002. The development of NPO entered a stable development period in 2005, and the research hotspots include “media”, “perception”, “management”, “policy”, and “management”. “After 2008, the hot keywords include “opinion”, “sentiment analysis”, “sentiment analysis”, “dynamics” and “public sphere”, which are all important elements of NPO research. These are all important elements of NPO, such as “media”, “perception”, “management”, “policy” and “online”. “sentiment analysis”, “dynamics” and “public sphere”, which are all important elements of NPO research. These are all important elements of NPO research.

In this study, VOSviewer and CiteSpace information visualization software were used to analyze 1385 documents for co-occurrence analysis, keyword mutation analysis and co-citation analysis, and information visualization was used as a means to analyze the current status of NPO research. The study concludes that the basic theory and research system in this field have been basically constructed, but the research directions are too concentrated and the frontier branches are too few. The data mining and analysis based on big data technology are increasingly demanding, and the logical relationships of data processing are becoming more and more complex. How to analyze and mine NPO information in heterogeneous data environment has become a major challenge for data management, application and value mining. Transforming big data public opinion into early warning, realizing in-depth analysis and accurate prediction of public opinion as well as improving the decision-making ability of public opinion are the future research directions of NPO. Therefore, our future plans is to use the system dynamics approach based on this research to study the dynamic evolution process of NPO, especially when an unexpected public health event occurs such as COVID-19, to provide countermeasures and suggestions for the government to strengthen the management of NPO on unexpected events, so as to strengthen the guidance of NPO on typical unexpected events, improve the network public opinion comprehensive governance level and promote the positive development of NPO.

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