A Bibliometric Analysis of Metaverse Studies (2000-2022) in China based on CiteSpace

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Abstract

As a new concept, the Metaverse is undoubtedly a hot-debated topic in recent years in the industry, media, and academia. Aided by CiteSpace software, with 242 journal papers of CNKI from 2000 to 2022 selected as the data source, a bibliometric analysis of Metaverse in China was conducted from the aspects of the number of journal papers, co-institutions, co-authors, and keyword co-occurrence network, etc. The results show that the Metaverse studies in China are still in their infancy, but the number of studies has shown explosive growth. The topics focus on the seven major parts, including virtual reality, algorithms, technical enablement, libraries, virtual world, digital technology, and blockchain. Current studies have deficiencies, such as a single perspective and an incomplete systematic research system. Relevant studies should pay attention to Metaverse studies, and interdisciplinary cooperation should be encouraged, speeding up establishing an organized research system, thus producing more high-quality research findings.

Keywords

Metaverse; Virtual World; Bibliometric Analysis; Citespace.

1. Introduction

Recently, the Metaverse has become a hot-debated topic in society. The emergence of metaverse detonated the Internet and showed a rapid trend spreading to other fields, which became a stimulant in various industries and academic areas. With the help of virtual reality (VR), augmented reality (AR), mixed reality (MR) technology, artificial intelligence (AI), big data, cloud computing and blockchain, Metaverse will become a way or field of human social life in the future, a new form of human civilization, which will weaken the boundary between the virtual world and real-world and affect the production and lifestyle of human society profoundly [1].

Like the Internet 30 years ago, Metaverse has brought challenges and opportunities: the challenge refers to the danger hidden behind Metaverse to the security of personal and national data, while Metaverse's empowerment education builds a new model of "smart +" education application [2]. And the opportunities refer to the virtual library model created by the empowerment library [3]. Faced with the opportunities and challenges contained in Metaverse, only by learning the development of Metaverse and identifying the opportunities and challenges can we better grasp the initiative and seize the opportunities to promote the healthy development of domestic Metaverse.

Therefore, aided by CiteSpace software, based on the data source of 242 journal papers downloaded on CNKI from 2000 to 2022, combined with a quantitative research method, a

bibliometric analysis of Metaverse in China was conducted from the aspects of the number of journal papers, co-institutions& co-authors, and keyword co-occurrence network, etc., to provide a theoretical reference for future studies.

2. Data and Tools

2.1. Analytical Tools

Bibliometric analysis is a research method of Scientometrics, which takes scientific knowledge as the research object, based on mathematics and statistics, and provides visual processing through computer technology. Finally, it presents the corresponding academic field's basic knowledge, structure, and evolution. As a visual data analysis software, CiteSpace can analyze and sort out the data with knowledge maps, and dig out the research hotspots, research trends and even the cooperative relations among universities and institutions in its academic field, which helps the researchers to learn the research trends more visually and conveniently [4]. Therefore, aided by the latest version of CiteSpace 6.1. R2 (64-bit), this paper conducted a bibliometric analysis of Metaverse studies (2000-2022) in China, including co-institutions, co-authors, and keyword co-occurrence networks, etc.

2.2. Data Sources

To ensure high interpretation, reliability and validity, all the data in this paper were collected from CNKI, with the retrieval keyword set as "Metaverse" and the time interval set from January 1, 2000, to May 8, 2022. A total of 1822 related papers were obtained. After repeated check and deduplication of retrieval results, 34 dissertations, non-academic documents, 1 conference notice, 610 newspapers, 247 characteristic journals, and 688 papers that did not conform to the theme were eliminated by manual screening. Finally, 242 valid journal papers were selected for this study.

3. The Bibliometric Analysis of Metaverse in China

3.1. The Annual Publication of Metaverse

To a great extent, the annual publication of papers can reflect the development trend of a field. With Excel adopted to statistically analyze the annually published papers of Metaverse on CNKI from 2000 to 2022, the timeline of the annually published papers of Metaverse was drawn (Figure 1). It can be seen from Figure 1 that the number of papers published on Metaverse in China can be roughly divided into two stages, namely, the embryonic period from 2000 to 2020 and the burst period from 2021 to 2022. As early as 2002, Han Minqing, a Chinese scholar, first put forward a brand-new concept of "Metaverse" in his paper "The Level of the Universe and the Metaverse" from a philosophical perspective [5]. In the next 20 years, no scholars in China have interpreted and studied the Metaverse. Until March 2021, Roblox, a well-known game company, was listed as "Metaverse's first share" on the New York Stock Exchange, and its market value soared tenfold. In October of the same year, Mark Zuckerberg renamed Facebook to Meta and announced its full-scale entry into the Metaverse. Metaverse instantly became the focus of worldwide attention. The domestic academic field once again started the metaverse research, and the findings showed explosive growth, from 0 articles in 2020 to 35 papers in 2021, and then to 204 papers on May 8, 2022. The related studies on Metaverse showed an exponential growth trend. Therefore, the domestic studies on Metaverse are in a period of rapid growth, and the associated studies will also keep growing in the future.
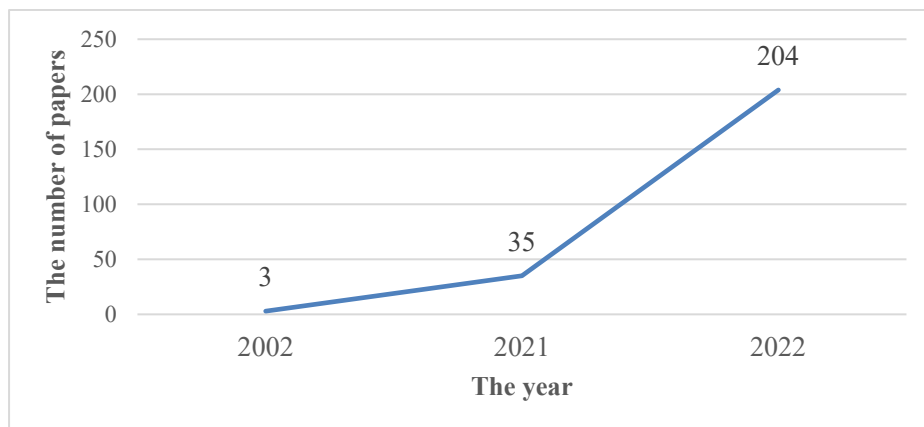
Fig 1. The timeline of the annually published papers of Metaverse from 2000 to 2022

3.2. Co-author's Networks

Using CiteSpace to analyze the authors, the following co-author's network map (Figure 2) is obtained. According to the number of published papers, the authors are imported into Excel, and the authors with 3 or more published papers are retained, thus obtaining the main author table (Table 1). The size of nodes and characters in the graph represents the author's publication volume. The larger the node, the larger the author's publication volume; The connection between nodes represents the cooperative relationship of co-authors, and the depth of connection means the close degree of co-authors.
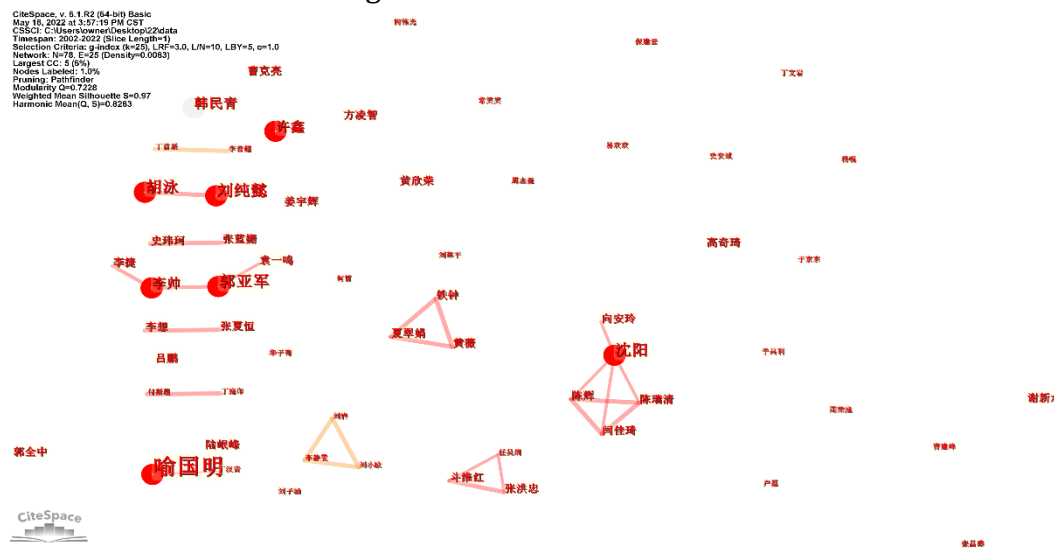

Fig 2. The co-author's network map

Table 1. Main authors Table

Rank	Author	Quantity of published papers	Rank	Author	Quantity of published papers
1	Yu Guoming	8	5	Guo Yajun	4
2	Liu Chunyi	4	6	Xu Xin	3
3	Hu Yong	4	7	Han Minqing	3
4	Shenyang	4	8	Li Shuai	3

Table 1 lists the main authors who have published 3 or more papers, among which Yu Guoming from Beijing Normal University has published 8 papers, ranking first. This scholar has made

outstanding achievements in the related research fields of the Metaverse. As can be seen from Figure 2, most authors exist independently and are distributed in scattered spots, such as Yu Guoming and Xu Xin; The proportion of co-authors is relatively small, among which there are 6 pairs of 2 people cooperating, such as Hu Yong and Liu Chunyi, Li Xiang and Zhang Xiaheng, etc. There are 3 pairs of 3 people cooperating, such as Tie Zhong, Xia Cuijuan and Huang Wei; a team of 4 people collaborating, such as a small cooperative relationship centered on Guo Yajun and Li Shuai; And a small cooperative network scattered around Shenyang. Overall, there is a less stable collaborative relationship between the authors, with higher independence but less cooperation.
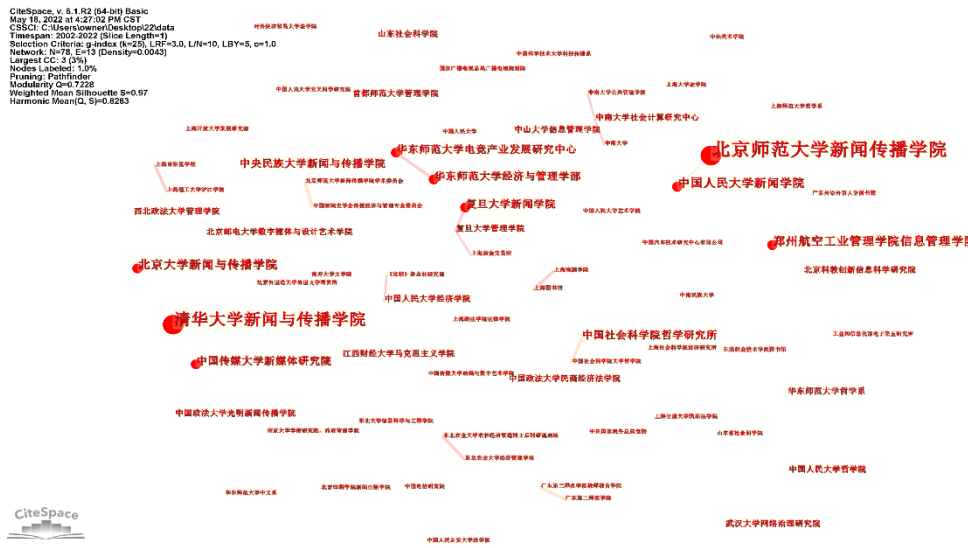
3.3. Co-institutions Network

Fig 3. The co-institutions network map

Table 2. Main institutions table

Rank	Research institutions	Quantity of published papers	Rank	Research institutions	Quantity of published papers
1	School of Journalism and Communication, Beijing Normal University	11	6	School of Journalism, Fudan University	3
2	School of Journalism and Communication, Tsinghua University	8	7	Department of Economics and Management, East China Normal University	3
3	School of Journalism, Renmin University of China	4	8	Institute of Philosophy, Chinese Academy of Social Sciences	3
4	School of Journalism and Communication, Peking University	4	9	Communication University of China, New Media Research Institute	3
5	Zhengzhou Institute of Aeronautical Industry Management, School of Information Management	4	10	East China Normal University E-sports Industry Development Research Center	3

To better understand the distribution of research forces in the Metaverse, according to the co-author's network, the co-institution network map is further made (Figure 3). The number of published papers by institutions is imported into Excel, and the institutions with 3 or more papers are retained, thus obtaining the main institution's table (Table 2). From Table 2, we can see that the School of Journalism and Communication of Beijing Normal University ranks first, with 11 papers published, which is in the core position, followed by Tsinghua University, School of Journalism and Communication (8 papers), Renmin University of China, School of Journalism and Communication (4 papers), Peking University School of Journalism and Communication (4 papers), Zhengzhou Institute of Aeronautical Industry Management, School of Information Management (4 papers), etc. Unlike the co-author's network map, the co- institution's network map is more scattered. It shows that even if there is a specific co-author relationship, they are basically from the same institution. For example, the small cooperation network with Shenyang as the core is from Tsinghua University, School of Journalism and Communication, Liu Chunyi and Hu Yong from Peking University, School of Journalism and Communication, and Guo Yajun and Li Shuai from Zhengzhou Institute of Aeronautical Industry Management, School of Information Management. Overall, there are a few stable cooperative groups in Metaverse studies in China, and most of them belong to the same institution, which shows the insufficient knowledge integration and agglomeration of Metaverse studies in China, indicating that the cooperative network with different researchers from different institutions has not yet been fully formed.

3.4. Keyword Co-occurrence Analysis

Word frequency analysis is an essential method for determining the research hotspots and frontier trends in a specific field. The keyword co-occurrence analysis of the papers published in a field can overcome the subjective judgment of researchers and objectively reflect the research hotspots in an area in a certain period [6]. This paper adopts CiteSpace 6.1. R2 (64-bit) to conduct a keyword co-occurrence analysis of 242 valid journal papers, thus obtaining the following keyword frequency table (Table 3), with import keywords of frequency no less than 4 imported into Excel. In addition, betweenness centrality is an important indicator. Papers with high betweenness centrality are usually the key to connecting the two fields, also called Turning Point in Citespace. The centrality in Table 3 can also reflect the importance of keywords to a certain extent. Except for the top three keywords of "Metaverse," "Virtual reality," and "Internet," the remaining keywords with higher centrality are "Digital twinning (0.32)", "Artificial intelligence (0.27)", "Virtual world (0.21)" and "Blockchain (0.16)".

Table 3. Keyword frequency table

Serial number	Keywords	Frequency	Centrality
1	Metaverse	208	1.24
2	Virtual reality	29	0.67
3	Blockchain	17	0.16
4	Digital twinning	14	0.32
5	Virtual world	8	0.21
6	Internet	8	0.34
7	Artificial intelligence	6	0.27
8	Digital economy	5	0.05
9	Virtual space	5	0.11
10	Application scenario	4	0.02
11	Algorithm	4	0.15
12	Library	4	0.05
13	Media convergence	4	0.11
14	Digital technology	4	0.08

CiteSpace can extract selected titles, keywords and abstracts for cluster analysis and display the analysis results concretely with maps, reflecting the research focus in a particular field [7]. In this paper, with the LLR algorithm adopted for clustering analysis, 15 keyword clusters are obtained, but only the first 7 clusters are retained for better analysis. The following keyword clustering map (Fig. 4) is received, and Excel further generates the clustering information table (Table 5). The research hotspots of Metaverse from 2000 to 2022 are concentrated in the following seven parts: Virtual reality, Algorithm, Technology empowerment, Library, Virtual world, Digital technology, and Blockchain.
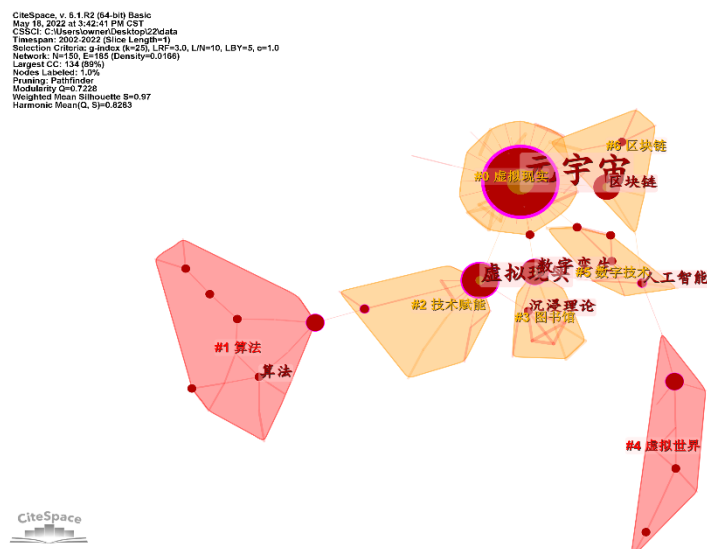

Fig 4. Keyword clustering map

Table 4. Clustering information table of LLR algorithm

Cluster ID	Size	Silhouette	Cluster Name	Top terms (log-likelihood ratio) (part)
# 0	43	1	Virtual reality	Virtual reality; Blockchain; Algorithm; Games; Library
# 1	17	1	Algorithm	Algorithm; Subjectivity; Users; Intelligent communication; Ethical reflection
# 2	14	0.967	Technology empowerment	Virtual reality; Technology empowerment; Scene; Embodied cognition; Narrative
# 3	12	0.98	Library	Library; Immersion theory; Mixed reality; News production; News product
# 4	11	0.871	Virtual world	Virtual world; Decentralization; Media technology; Virtual civilization; Centralization
# 5	9	0.973	Digital technology	Digital technology; Information dissemination pattern; Media convergence; Mainstream media; Artificial intelligence
# 6	9	0.828	Blockchain	Blockchain; Digital economy; Value circulation; Infrastructure; Radio and TV

(1) Virtual Reality

Virtual reality (VR) is one of the core concepts of the Metaverse. According to Zhou Zhiqiang's study, the Metaverse is a digital space that allows people to immerse themselves in virtual reality by combining human perception technology with the digital Internet [8]. Metaverse,

relying on virtual reality technology, can meet the needs of learning with changing scenes and realize integrated learning; that is, under the learning scene of the Metaverse, the learning activity of virtual and real integration composed of learners, their time, space and learning events and form a specific integrated setting with the particular empowerment technology [9]. The spatiality of the Metaverse also provides practical possibilities for the virtual avatar of game users. Users can get social presence through virtual reality technology, subjectively interpret the digital availability of virtual space, and enhance their game experience [10].

(2) Algorithm

The algorithm is one of the underlying technical foundations of the Metaverse, which has a crucial influence on the Metaverse's connection rules and social structure in the future. The development of algorithm technology presents a process of iterative change. From the initial as a cognitive intermediary to the present, machine deep-learning algorithms are constantly evolving according to the data fed back by people. People gradually gain knowledge of interacting with algorithms in their experiences. The role of algorithms and their relationship with people in the Metaverse will become more and more critical [11]. According to Tan Tian's study, user production recommended algorithm and the Metaverse are three communication revolutions in the half-century since the birth of the Internet, which will affect the effect and influence of social communication. Human beings will face more tests in technical ethics, communication ethics, and human nature [12].

(3) Technology empowerment

Metaverse is not a new technology but the product of the comprehensive integration of existing IT technology, and it is the collective product of the latest stage of information development. Metaverse and technology complement each other, and technological upgrading is the key driving force for Metaverse's development and progress. The development of Metaverse will promote upgrading existing technologies and the emergence of new technologies. Wang Wenxi and others reviewed the critical technologies of the Metaverse. He believed that the essential technologies of Metaverse mainly include the following five aspects: network and computing technology, management technology, virtual and real object connection, modeling and management technology, virtual and real space interaction, fusion technology, etc. [13]. Metaverse itself, as a collection of technologies, will not only promote the development of virtual reality and empower education to build a new model of "intelligent +" education application [2] but also empower libraries to build a virtual library model [3].

(4) Library Research

Metaverse's studies on libraries are mainly reflected in the development of Metaverse's enabling libraries. The empowerment of the Metaverse Library promotes the transformation of the library into intelligence and immersion. Based on summarizing the core concepts of empowering virtual libraries in the Metaverse, Guo Yajun, and others put forward five application scenarios for empowering virtual libraries in the Metaverse and put forward the development strategy framework of empowering virtual libraries in the Metaverse [3]. Zhang Xingwang discussed the origin, connotation, and characteristics of the integration of library and Metaverse theory, designed and constructed the corresponding system, and analyzed the development trend of library Metaverse [14]. Xin Haixia also discussed the future development direction of the Metaverse Library [15].

(5) Virtual World

Metaverse integrates augmented reality (AR), virtual reality (VR), and mixed reality (MR) to varying degrees, creating a mirror virtual world with the development of digital twinning technology. Therefore, the virtual world is a hot topic in the Metaverse. Wang Haidong believes that the Metaverse is a virtual space built based on mobile Internet and with the help of various digital technologies, which are both mapped and independent of the real world. Metaverse has

experienced the 1.0 era, is in version 2.0, and is moving towards the future version 3.0. metaverse is independent of the real world and forms a new virtual civilization [16]. Fang Lingzhi and others further pointed out that the Metaverse is an upgraded virtual world. Still, there are significant differences between it and the virtual world in constructing technology and humanities. Building metaverse requires not only powerful and intelligent hardware and software but also a strong foundation for blending [17].

(6) Digital technology

Digital technology is one of the critical technologies of the Metaverse. Many communication technologies, Internet technologies, and digital technologies have been continuously integrated into the metaverse and become the top-level technologies of the metaverse [1]. Zhang Xiaheng and Li Xiang pointed out that driven by information technology, Internet technology, and the new generation of digital technology, and information resources are mainly produced, stored, and used in digital form. Therefore, from the perspective of information resource management, based on the elements of Metaverse architecture, they put forward the metaverse framework for information resource management and put forward the optimization direction of information resource management based on metaverse. By promoting digital technology in the Metaverse scene ecosystem, we can enrich the imagination and experience of the scene ecosystem, successfully combine the real-world scene ecosystem with the virtual world ecosystem and enable scene consumers to realize an immersive experience [18].

(7) Blockchain

Blockchain technology is a critical security technology in the Metaverse. Many users in the Metaverse platform need to use the decentralized underlying technology to ensure the platform's security. The decentralized and unchangeable characteristics of blockchain match well with its needs. In addition, the determination of digital assets in the Metaverse also needs blockchain technology as the ownership certificate of digital goods and assets to reconstruct and protect the value of digital assets in the Metaverse [19]. The research of Gao Yicheng and Yang Dong pointed out that the risk of domestic data security in China doubled in the metaverse era. The unified data security governance model ceased to exist, but was carried out between data development, utilization, and data protection. Blockchain technology was a critical link to achieving comprehensive governance [20]. Since the core of the metaverse is "decentralization," the governance experience of building decentralized autonomous organizations using blockchain technology can provide some reference for organizational autonomy within the Metaverse [21].

4. Conclusion

4.1. Research Findings

With the help of CiteSpace visual analysis software, this paper sorts out journal papers on the Metaverse published on CNKI from 2000 to 2022. It analyzes the current situation of Metaverse studies in China from the aspects of annual publication volume, co-institutions and co-authors, keyword co-occurrence and clustering networks, etc. It is found that the studies on Metaverse have shown explosive growth in the past two years; The core authors are Yu Guoming, Liu Chunyi, Hu Yong, Shenyang, Guo Yajun, etc. The leading research institutions are concentrated in the School of Journalism and Communication of major universities, such as Tsinghua University School of Journalism and Communication of Beijing Normal University, Renmin University of China School of Journalism and Communication, Peking University School of Journalism and Communication, etc. The research hotspots in this field mainly include virtual reality, algorithms, technology empowerment, library, virtual world, digital technology, and blockchain. With the deepening of Metaverse studies, based on these seven core hot spots, more research hotspots will be discovered by scholars in the future.

4.2. Deficiencies and Prospects

The above analysis shows that the related studies on Metaverse are in their infancy in China, and scholars have studied the Metaverse from different perspectives. Based on the research findings, the following suggestions are put forward for the future studies on Metaverse in China:

(1) Pay attention to the studies on the Metaverse. There is a big gap between the studies on metaverse at home and abroad. As an "exotic product," the studies on Metaverse abroad are earlier than in China, with a more extended research cycle, more in-depth studies, and fruitful academic achievements. Metaverse is highly prevalent both at home and abroad, but the number of Chinese scholars is insufficient, with fewer achievements, reflecting that Chinese scholars pay inadequate attention to the Metaverse. Therefore, domestic scholars should strengthen their awareness and studies on Metaverse.

(2) Carry out interdisciplinary, in-depth studies from multiple angles. At present, the disciplines of related research are concentrated. Most of them focus on the perspective of journalism and communication, discussing the concept and development of the Metaverse, ignoring the influence of the Metaverse on society and human beings. Scholars should carry out interdisciplinary research, combining sociology, economics, and other related disciplines with Metaverse studies. In addition, it is necessary to track the latest progress of foreign metaverse research in time to inject fresh blood into domestic metaverse research and provide new inspiration and research ideas.

(3) Strengthen cooperative research and accelerate the formation of a systematic research structure. There are few stable cooperative relations among authors, with substantial independence and less cooperation. Simultaneously, collaboration between different institutions is relatively scarce. Most of them are internal cooperation among institutions, and there is still no systematic research structure. Scholars should strengthen collaboration and establish a high-yield, mature, and formal cooperative relationship among individuals or research institutions to improve research efficiency and learn from each other's strengths to enhance the quality of research output.

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