Postprint: A Study on the Evolutionary Process and Progress of China's Five Metrics

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Abstract

[目的/意义]Bibliometrics, scientometrics, informetrics, webometrics, and knowledgometrics are collectively termed the "Five Metrologies," representing an important research direction in information science. Through literature-based thematic investigation, this study quantitatively analyzes the developmental status of China's "Five Metrologies," examines the evolutionary trajectories of thematic branches and disciplinary construction progress, to provide references for future development.[方法/过程]A "six-dimensional research framework" was designed to investigate data across six dimensions: research output, research funding, curriculum education, talent and institutions, scientific evaluation, and software/tools. CiteSpace was then employed to generate temporal evolution maps of literature themes, analyzing the evolutionary processes and current developmental status of each "Five Metrologies" branch in China.[结果/结论]The findings reveal that the influence of China's "Five Metrologies" has significantly increased, demonstrating outstanding performance in publication volume, project support, curriculum education, and practical applications. The capacity for independent innovation has been strengthened: on one hand, numerous Chinese databases and literature analysis tools have been developed to address domestic issues; on the other hand, research has shifted from introducing and validating foreign studies during the discipline's initial stage to innovating theories, methods, tools, and applications. Interdisciplinary characteristics are prominent, integrating methodologies from mathematics and computer science and applying them to frontier prediction and core author identification in medicine, chemistry, and other fields. The breadth of research objects has expanded to encompass documents, scientific activities, network information, and knowledge resources. Research content has undergone fine-grained differentiation from document carriers to knowledge units.

Full Text

Preamble

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Research on the Evolution and Progress of China's "Five Metrics"

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Abstract

[**Purpose/Significance**] Bibliometrics, scientometrics, informetrics, webometrics, and knowledgometrics—collectively known as the "Five Metrics"—represent important directions in information science research. Through literature theme investigation and quantitative analysis, this study examines the current development status of China's "Five Metrics," 梳理 the thematic evolution process and disciplinary construction progress of each branch, with the aim of providing references for future development. [**Method/Process**] This study designs a "Six-Dimensional Research Framework" to conduct data investigations from six dimensions: scientific research output, research funding, curriculum education, talent and institutions, scientific evaluation, and software/tools. CiteSpace is then employed to generate chronological thematic evolution maps to analyze the evolutionary process and development status of each branch of China's "Five Metrics." [**Result/Conclusion**] The findings reveal that China's "Five Metrics" research has significantly increased in influence, demonstrating outstanding performance in publication volume, project support, curriculum education, and practical applications. The research shows enhanced independent innovation awareness, with Chinese scholars developing Chinese databases and analytical tools tailored to domestic issues, while shifting from introductory and validation studies of foreign literature in the early disciplinary construction stage to innovative research on theories, methods, tools, and applications. The interdisciplinary characteristics are prominent, as the discipline not only integrates methods and technologies from mathematics and computer science but also finds applications in frontier prediction and core author identification in fields such as medicine and chemistry. The breadth of research objects has expanded to include documents, scientific activities, network information, and knowledge resources. Research content has evolved from document carriers to fine-grained differentiation of knowledge units.

Classification Number: G250

Keywords: "Five Metrics"; Six-Dimensional Research Framework; Evolution Analysis; Visualization

On September 8, 2017, the National Committee of the Chinese People's Political Consultative Conference held a bi-weekly consultation meeting, proposing to "optimize the innovation environment and reform the science and technology evaluation system." As scientific evaluation constitutes a major practical application of metrics, research on the evolution and progress of the "Five Metrics" holds practical significance under the policy guidance and actual demands of scientific evaluation work. From October 20, 2017, the 16th International Conference on Scientometrics and Informetrics (ISSI), co-hosted by the Chinese Association for Science of Science and S&T Policy and Wuhan University's Research Center for Chinese Science Evaluation, was held in Wuhan. This ISSI conference marked the second time China has hosted the event since its inception in 1987, demonstrating China's influence in international metrics research. At this conference, "Five Metrics" (FiveMetrics) appeared for the first time in the ISSI conference themes.

This study aims to systematically review "Five Metrics" research in China, explore the origins and evolution of its five branches, and clarify the relationships among them.

1. Overview of the "Five Metrics"

Bibliometrics, scientometrics, informetrics, webometrics, and knowledgometrics are collectively referred to as the "Five Metrics," representing a new developmental stage in information measurement following the "Three Metrics." The term "Five Metrics" officially emerged at the 16th ISSI conference, marking the formal establishment of the "Five Metrics" system. Existing literature surveys indicate that this terminology originated in China, as no equivalent "Five Metrics/Metric" expression has appeared abroad.

1.1 Origins and Formation of the "Five Metrics"

Early explorations in "bibliometrics" began in 1917 when F.T. Cole and N.B. Eales conducted statistical analyses of publications in comparative anatomy [1]. The subsequent birth of the three major bibliometric laws laid the theoretical foundation for the discipline. In 1955, Garfield systematically proposed the citation indexing method for literature retrieval and established the Science Citation Index (SCI) database in 1963. The starting point for domestic research was in 1964 when Zhang Qiyu and Wang Enguang [2] published an article in *Comprehensive Science and Technology Intelligence Work* introducing the American *Science Citation Index*. Pritchard formally proposed the term "Bibliometrics" in 1969, marking the birth of bibliometrics as a discipline [3]. In 1980, Chinese scholar Wang Jinsheng [4] introduced Bradford's Law, while Liu Zhihui [5] introduced quantitative research methods for scientific literature. In 1981, Chen Guangzuo [6] pointed out the limitation of Bradford's Law in favoring journals

with high publication volumes and proposed improved methods for determining core journals. From the perspective of journal literature, the 1980s marked the beginning of bibliometrics research in China.

Concurrent with early bibliometrics explorations, Polish scholars Otto and Maria Ossowska first proposed the concept of "science of science" in 1936. J.D. Bernal's 1939 publication *The Social Function of Science* officially inaugurated science of science research. Price proposed the exponential growth law of science in 1949 and published *Science since Babylon* (1961) and *Little Science, Big Science* (1963), which synthesized outstanding quantitative research achievements from nearly a century of pioneering work and formally opened the new field of "scientometrics" [7]. Price is thus honored as the "father of scientometrics." The specialized journal *Scientometrics* was launched in 1978. Chinese scholar Zhao Hongzhou [8] introduced the concept of scientometrics to China in 1979, and the Chinese Association for Science of Science and S&T Policy was established in 1982.

In the late 1970s, with the rapid development of information technology and increased social informatization, the concept of informetrics gradually separated from bibliometrics. In 1979, Otto Nacke proposed the concept of informetrics, separating it from bibliometrics and expanding the scope of measurement objects [9]. Chinese scholar Liu Da [10] introduced this new field—informetrics—in 1981. China unified the terminology as "information metrology" in 1992 when the State Science and Technology Commission changed "scientific and technical intelligence" to "scientific and technical information," after which the intelligence science community uniformly translated "information" as "信息" [11]. In 1994, Liu Tingyuan [12] compared the differences and connections among bibliometrics, scientometrics, and informetrics.

The development of information science and the growing volume of networked data continuously expanded the research objects of informetrics. As early as 1990, P. William [13] proposed applying informetric methods to electronic communication. In 1997, T.C. Almind and P. Ingwersen [14] published "Informetric Analyses on the World Wide Web," initiating webometrics research. Domestically, Xu Jiuling and Qiu Junping conducted comprehensive, systematic, and in-depth analyses of webometrics in 1999 and 2000, respectively [15-16].

Influenced by Popper's theory, Brookes advocated that the task of information science is to explore and organize objective knowledge. The exploration and analysis of knowledge resources inevitably became the development direction of information science research [17]. In 2001, Wang Xukun [18] first proposed the concept of knowledgometrics and suggested establishing it as a discipline. Inspired by OECD's 1996 reports *The Knowledge-Based Economy* and *National Innovation Systems*, Chinese scholar Liu Zeyuan [19] systematically discussed the definition of knowledgometrics in 2002. Based on existing literature, the term "Knowledgometrics" first appeared abroad in 2006 [20].

1.2 Comparative Study of the "Five Metrics"

The five branches of the "Five Metrics" are distinct yet closely related in theoretical foundations and research objects, as shown in Table 1 .

Table 1. Comparative Study of the "Five Metrics"

Discipline	Originators (International)	Originators (Domestic)	Research Objectives	Research Objects
Bibliometrics	Pritchard	Zhang Qiyu, Wang Enguang	Quantitative study of relationships among scientific literature using applied mathematics and statistics	Bibliographies, abstracts, indexes, scientific literature, scientific journals, documentation institutions
Scientometrics	Price	Zhao Hongzhou, Jiang Guohua	Quantitative analysis of inputs, outputs, processes, and patterns in scientific activities	Scientific activities
Informetrics	Otto Nacke	Wang Jinsheng, Liu Zhihui, Liu Da	Quantitative analysis of phenomena, processes, and patterns in information activities	Information and information activities
Webometrics	Almind, Ingwersen	Xu Jiuling, Qiu Junping	Quantitative analysis of quantitative relationships among network information resources and their carriers	Network information resources and carriers

Discipline	Originators (International)	Originators (Domestic)	Research Objectives	Research Objects
Knowledgometrics	Brookes	Wang Xukun, Liu Zeyuan	Quantitative analysis of relationships among knowledge units and knowledge activities	Knowledge units, knowledge activities

Pritchard emphasized the application of mathematical and statistical methods in bibliometrics [21]. After bibliometrics was introduced to China, Wang Xianlin [22] summarized its research objects as abstract indexes, citations, journal guides, union catalogs, and reader borrowing records from intelligence units, while Qiu Junping [1] believed that bibliometrics research objects also include author numbers, reader feedback information, and documentation work systems (libraries, intelligence units).

The research purpose of scientometrics is to explore the inherent laws of scientific development from a quantitative perspective. Although it shares similarities with bibliometrics in studying the patterns of scientific literature, their focuses differ. However, they are similar in research objects and methods, with scientometrics being an important branch of science of science.

When Otto Nacke proposed the term informetrics, he also emphasized its combination with mathematical methods [23]. Chinese scholar Liu Da [10] defined it as quantitatively analyzing the dynamic characteristics of intelligence when first introducing “informetrics” to China. Wang Hongxin [24] believed that the object of informetrics is information phenomena in the scientific communication process. Bibliometrics, scientometrics, and informetrics have overlapping theoretical foundations and research methods.

2. Framework Structure and Data Sources

The meanings of each branch in the Six-Dimensional Research Framework and common data sources are shown in Table 2 .

Table 2. Framework Structure Analysis

Dimension	Definition	Common Data Sources
Scientific Research Output	Creative results obtained by researchers through experimental observation, investigation, and comprehensive analysis within a specific scientific research project scope, confirmed through review or appraisal as having academic significance and practical value [36], such as journal articles, dissertations, monographs, patents, and research reports	Web of Science, EI, Scopus, Derwent, CA, EBSCO, CALIS Union Catalog, Superstar Chinese E-books, Duxiu Academic Search, Wanfang, CNKI, CSSCI
Research Funding	Specialized research projects funded by national education management departments at all levels or through industry-university-research cooperation funding from enterprises and institutions	National Natural Science Foundation, National Social Science Foundation, National Science Fund for Distinguished Young Scholars, Ministry of Education Humanities and Social Sciences Research Projects
Curriculum Education	"Five Metrics" related courses offered by universities for undergraduates and graduate students	University websites, curriculum survey questionnaire data

Dimension	Definition	Common Data Sources
Talent and Institutions	High-productivity authors, highly-cited authors, or core authors in "Five Metrics" research; laboratories, research institutes, or research centers continuously funded by provincial education management departments or university management departments	University websites, journal articles
Scientific Evaluation	Evaluation applications including talent evaluation, institutional evaluation, journal evaluation, and website evaluation	Chinese Science Evaluation Network, Best University Network, Chinese Alumni Association Network
Software and Tools	"Five Metrics" data support tools such as literature title analysis tools and citation databases	Baidu Baike, journal articles

In selecting scientific research output, this study only includes academic papers and monographs for data comprehensiveness and availability. For research funding, only projects from the National Natural Science Foundation (referred to as "Natural Science") and the National Social Science Foundation (referred to as "Social Science") are selected. Specific paper data sources are limited to CNKI, with the search formula: KY="informetrics" OR KY="bibliometrics" OR KY="webometrics" OR KY="scientometrics" OR KY="knowledgometrics" OR KY="content analysis" OR KY="cooperation analysis" OR KY="citation analysis" OR KY="knowledge mapping" OR KY="visualization analysis" OR KY="term frequency analysis" OR KY="co-citation analysis" OR KY="Altmetric" OR KY="alternative metrics" OR

KY="co-word analysis". This retrieved 22,730 paper data entries, with the search date being November 30, 2017. In selecting the search formula, the five specific terms of the "Five Metrics" were first used as keywords for initial retrieval. High-frequency keywords were then selected from the results for secondary retrieval. After multiple rounds of secondary retrieval, the above 15 keywords were found to be the most accurate and comprehensive combination.

Additionally, to study the publication patterns of each "Five Metrics" branch, the author used the OR operator to connect the following subject terms: "bibliometrics/Bibliometric*" OR "scientometrics/Scientometric*" OR "informatics/Informetric*" OR "webometrics/Webometric* OR Cybermetric*" OR "knowledgometrics/Knowledgeometric* OR KnowledgeMetric*" for subject searches in CNKI and Web of Science (limited to SCIE and SSCI citation indexes). The Web of Science database was limited to mainland China and Taiwan to count English papers published by Chinese scholars. The search date was the same as above. After manual deduplication and removal of irrelevant literature, the combined results from both databases yielded total publication counts: bibliometrics (12,016), scientometrics (1,753), informetrics (645), webometrics (412), and knowledgometrics (50), with literature time distributions from 1980 to 2017 (referred to as Search Method 2). To ensure comprehensive retrieval rates for each "Five Metrics" branch, papers with multiple themes were counted cumulatively when calculating branch-specific quantities. Additionally, only one paper was retrieved with "Five Metrics" as the exact subject term. As it appeared repeatedly in the subject retrieval results for each branch term, it was also processed with cumulative statistics.

3. Research Results

The Six-Dimensional Research Framework reflects the quantitative relationships in the evolution of each "Five Metrics" branch, while spatiotemporal migration maps drawn by CiteSpace can display the evolution process from a content perspective.

3.1 Six-Dimensional Data Analysis Results for the "Five Metrics"

3.1.1 Scientific Research Output (1) Academic Papers. Based on Search Method 2 results, an area chart of annual publication distribution for each "Five Metrics" branch was drawn (Figure 2 [Figure 2: see original paper]). The area enclosed by the line and axes represents the total publication volume for the corresponding branch, with coordinate points on the line indicating annual publication volumes. The topmost line represents the annual distribution from Search Method 1.

Figure 2 shows that bibliometrics, as the foundation and starting point of the "Five Metrics" theoretical system, has significantly higher total and annual publication volumes than the other four branches. Moreover, bibliometrics research publications have generally shown a growth trend over time, with only a slight

decline in 2013, indicating that bibliometrics research has not been eliminated with the development of metrics but continues to innovate under new data and technological environments. Scientometrics ranks second in publication volume, informetrics slightly higher than webometrics in third place, while knowledgometrics, as an emerging branch, shows the lowest publication volume and smallest area in the chart. The correlation coefficient $R^2 = 0.951$ for the total publication volume curve of the "Five Metrics," indicating that publication growth conforms to the exponential growth law of literature information. Figure 2 also reflects that China's "Five Metrics" research is in a rapid growth stage, remaining a hot topic in future information science research.

(2) Academic Monographs. An academic monograph is a work that provides relatively concentrated, systematic, comprehensive, and in-depth discussion of a specific discipline, field, or topic [37]. Using Superstar Digital Library, Duxiu, Douban, and other book resource platforms, as well as Wuhan University Library collections, this study investigated the publication of "Five Metrics" academic monographs. Selected monographs closely related to the five theoretical branches are listed in chronological order by publication year in Table 3 . "Five Metrics" research monographs can be divided into two categories: those providing detailed theoretical discussions (commonly used as course textbooks) and those focusing on methods, tools, empirical studies, etc. (more numerous and frequently updated with information technology development). This section only lists the first category of theoretical works.

As shown in Table 3, the most highly cited work is Qiu Junping's *Bibliometrics*, originally a teaching material for Wuhan University's School of Library and Information Science in 1984 and formally published in 1988. Together with Luo Shisheng's *Introduction to Bibliometrics* and Wang Chongde's *Bibliometrics Course*, these were the earliest systematic introductions to bibliometrics research in China and served as 启蒙 textbooks for metrics research.

In terms of publication time, bibliometrics monographs were published earlier on average than other metrics branches. Scientometrics and informetrics theoretical monographs were concentrated between 2000-2010, with post-2010 publications focusing more on methodology, case studies, or application research. Highly cited webometrics monographs were published around 2010. Knowledgometrics was proposed relatively recently, and currently has the fewest monographs.

3.1.2 Research Funding National Social Science Foundation projects and National Natural Science Foundation projects were extracted from the CNKI search results. Missing fields were supplemented using the National Social Science Foundation project database and National Natural Science Foundation shared service network, including project approval numbers, types, titles, discipline classifications/keywords, approval years, principal investigators, and funding amounts. Projects in library, information, and archival science were manually labeled based on field information, and "Five Metrics" related projects

were then screened through project titles and investigators to analyze funding support for "Five Metrics" research in China.

After deduplication, 197 National Social Science Foundation projects related to "Five Metrics" themes were obtained, including 91 projects in the first-level discipline of library, information, and archival science, with 41 "Five Metrics" related theme projects. National Natural Science Foundation data yielded 417 entries after deduplication, including 169 projects in the management and information science departments, with 34 "Five Metrics" related projects. A distribution map by project type and approval year is shown in Figure 3 [Figure 3: see original paper], with bar charts showing annual distribution by type for Social Science Foundation projects and line charts for Natural Science Foundation projects.

Figure 3 indicates that funding for "Five Metrics" research in China began in 1996, with growth in both quantity and project types starting in 2004. Between 1996-2004, only Social Science youth projects and Natural Science general projects existed, with an average of only one funded project per year. No "Five Metrics" related projects appeared in Social Science Foundation funding between 1997-2003. Between 2004-2016, four major Social Science projects were funded, indicating strong support for "Five Metrics" related research and confirming that "Five Metrics" has become an important branch of information science research in China.

To further analyze the thematic distribution of funded projects in the "Five Metrics" theoretical system, keyword fields were manually supplemented for Social Science Foundation projects by assigning 2-3 keywords based on "project titles" and "project introduction." Synonym merging was performed for keywords from both Social Science and Natural Science Foundation data to generate a "project theme-project number" two-mode matrix, and a cluster map was drawn using Netdraw (Figure 4 [Figure 4: see original paper]). In Figure 4, square nodes represent project themes, circular nodes represent project numbers, and arrows indicate affiliation relationships between approval numbers and themes.

Figure 4 shows that the scientific evaluation cluster has the most nodes. As an important social application of the "Five Metrics" theoretical system, this research direction is most likely to receive funding, reflecting national demand for scientific evaluation using "Five Metrics." Bibliometrics, scientometrics, informetrics, and webometrics nodes also have high centrality, indicating substantial national funding support for these branches. Knowledgometrics emerged most recently, with only two funded projects to date. Additionally, patent analysis, citation analysis, and knowledge mapping have formed clear clusters, representing important content in China's "Five Metrics" research.

3.1.3 Curriculum Education According to China's *Undergraduate Major Catalogue of Regular Higher Education Institutions (2012)*, library, information, and archival management (1205) includes three undergraduate majors: library

science, archival science, and information resource management. The *Catalogue of Disciplines and Majors for Doctoral and Master's Degrees* issued by the Academic Degrees Committee of the State Council includes three second-level disciplines under the first-level discipline of library, information, and archival management: library science, information science, and archival science.

According to the *Chinese University and Discipline Evaluation Report (2017-2018)* and *Chinese Graduate Education and Discipline Evaluation Report (2017-2018)*, 51 Chinese universities currently offer undergraduate majors in library, information, and archival management, and 65 universities offer graduate programs. The top 10 universities in the graduate education ranking were selected to investigate their "Five Metrics" curriculum offerings through questionnaires and interviews (Table 4).

Table 4 shows that informetrics courses currently dominate "Five Metrics" curriculum education and are essential in universities offering "Five Metrics" related courses. "Five Metrics" curriculum education focuses primarily on graduate education. Wuhan University's School of Information Management, as a leading institution in China's "Five Metrics" research, offers the most comprehensive curriculum related to the "Five Metrics" theoretical system. Jilin University offers informetrics courses not only in its Management School but also in its School of Public Health, with different emphases—the latter focusing more on medical applications. Wuhan University's Information Resource Measurement Issues Research and Sun Yat-sen University's graduate course Information Metrics and Evaluation both include webometrics content. Renmin University of China does not directly offer "Five Metrics" related courses. The survey results show that institutions with significant publication volumes in "Five Metrics" research, such as Dalian University of Technology, Beijing University of Technology, Shanxi University, Zhengzhou University, Institute of Scientific and Technical Information of China, and National Science Library, Chinese Academy of Sciences, also offer related courses. Notably, although Dalian University of Technology has not yet established library, information, and archival management majors, its Institute of Science of Science and S&T Policy offers scientometrics as a required course for science of science graduate students.

3.1.4 Talent and Institutions (1) Core Researchers. Authors with publication counts $ $30 and their citation status are shown in Figure 5 [Figure 5: see original paper].

Figure 5 shows that highly productive authors in China's "Five Metrics" research include Qiu Junping, Liu Zeyuan, Zhao Rongying, Jiang Chunlin, and Cui Lei, while highly cited authors include Qiu Junping, Liu Zeyuan, Chen Yue, Cui Lei, and Zhao Rongying.

(2) Research Institutions. Among Chinese universities offering library, information, and archival management programs, eight have established specialized

laboratories or research centers for “Five Metrics” theoretical system research (Table 5).

The establishment of physical institutions such as laboratories or research centers provides equipment, environment, and funding guarantees for “Five Metrics” research, reflecting the discipline’s importance and facilitating its development. In addition to contributing substantial publications, each institution has developed characteristic “Five Metrics” application products, such as the knowledge mapping analysis tool CiteSpace developed by WISE Lab of Dalian University of Technology in cooperation with Drexel University, the CSSCI database developed by Nanjing University’s Chinese Social Sciences Research Evaluation Center, and university rankings released by Wuhan University’s RCCSE. From the nature of research centers, scientific evaluation research centers constitute the main form of “Five Metrics” research institutions. Combined with funding data, we can conclude that scientific evaluation based on “Five Metrics” is an important application of the discipline with high academic value and social significance. Geographically, “Five Metrics” research institutions are concentrated in central and eastern China, with only one institution in southwestern China. Since “Five Metrics” research is not limited by geography or environmental factors, research centers still have development space.

3.1.5 Scientific Evaluation Scientific evaluation is a major application of the “Five Metrics.” Based on evaluation objects, it can be divided into institutional evaluation, journal evaluation, discipline evaluation, and academic evaluation (Figure 6 [Figure 6: see original paper]).

The most important outcome of institutional evaluation is university ranking. The quantitative analysis methods and academic influence evaluation methods used in “Five Metrics” research are widely applied in university evaluation practice. National-level applications include the “985 Project,” “211 Project,” and “Double First-Class” university lists. Currently influential third-party university rankings in China include ShanghaiRanking’s Academic Ranking of World Universities, RCCSE University Rankings, Erisson Chinese Alumni Association University Rankings, and Wu Shulian’s University Rankings, in addition to world university evaluations. Notably, university evaluation is a complex and comprehensive interdisciplinary application where “Five Metrics” collaborates with economics, mathematics, statistics, and other disciplines.

Journal evaluation involves ranking academic journals. In addition to theoretical research on impact factors, journal influence rankings are major outcomes, such as the Chinese Social Sciences Citation Index (CSSCI), Peking University Chinese Core Journals, and RCCSE Chinese Academic Journal Evaluation Research Report. Journal evaluation results are mainly used for institutional research award classification.

Discipline evaluation applications include Ministry of Education discipline assessments, “Double First-Class” discipline lists, RCCSE Chinese Graduate Ed-

ucation and Discipline Evaluation Reports, and discipline research frontier reports.

Academic evaluation includes paper influence evaluation and scholar influence evaluation, such as highly-cited author statistical reports and ESI indicators.

Overall, "Five Metrics" applications in scientific evaluation can be divided into two levels: evaluation methods and evaluation indicators. Evaluation methods include quantitative analysis, citation analysis, and term frequency analysis. Evaluation indicators mainly include publication and citation counts in core journals (SCI/SSCI/CSSCI, etc.), patent counts, highly-cited paper counts (ESI), conference paper counts, and funded project counts as scientific output indicators.

3.1.6 Software and Tools Literature information analysis tools are characteristic instruments for "Five Metrics" research, while citation databases provide data support for citation analysis. Table 6 summarizes independently developed "Five Metrics" data analysis software and major Chinese citation databases.

In software development, although many mature foreign software packages exist for visualization, literature statistics, and social network analysis (e.g., Pajek, Netdraw, BibExcel), most are designed for foreign database formats like Web of Science and Scopus and have poor compatibility with Chinese databases and texts. To address these issues, Chinese scholars have developed multiple data analysis tools for domestic database analysis needs, providing convenience for "Five Metrics" research in China. For example, the SATI (Statistical Analysis Toolkit for Informetrics) developed by Ye Ying's team can achieve bibliographic format conversion, field information extraction, term frequency statistics, and knowledge matrix construction, with good compatibility for CNKI and CSSCI database data [38]. Wang Wei [39] noted that the most challenging problems in bibliometrics teaching and research are data acquisition and orderly processing of large samples. His team's CDSAS (Compact Disc Database Statistical Analysis Software) was developed for commonly used domestic and international biomedical CD database file formats and can be adjusted to analyze all CD databases through parameter settings. Professor Shen Yang's ROST Content Mining Tool has wide applications in journalism and communication and also performs well in literature information processing due to its excellent text processing, word frequency statistics, segmentation, and sentiment analysis functions [40]. Professor Cui Lei's team developed BICOMB (Bibliographic Item Co-occurrence Matrix Builder) for text mining and bibliometrics research [41].

In citation databases, the emergence of the American Science Citation Index greatly promoted citation analysis research. China subsequently accelerated construction of Chinese journal citation index databases. The Chinese Science Citation Database (CSCD) filled the gap in Chinese citation databases in 1995, followed by the Chinese Social Sciences Citation Index (CSSCI) in 2000. The Chinese Scientific and Technical Papers and Citations Database (CSTPC), de-

veloped by the Institute of Scientific and Technical Information of China and Wanfang Data in 1996, includes paper and citation databases. The Chinese Citation Database (CCD) includes references from all source database products published by China Academic Journal (CD Edition) Electronic Magazine, covering over ten million cited documents including journals, dissertations, conference papers, books, patents, standards, newspapers, etc. [42].

3.2 Evolution of "Five Metrics" Research Themes in China

Search Method 1 results were imported into CiteSpace to generate a timeline evolution map of "Five Metrics" research themes in China (Figure 7 [Figure 7: see original paper]). Starred nodes represent bibliometrics (or bibliometric), scientometrics, informetrics, webometrics, and knowledgometrics keywords. Node times indicate when themes first appeared. Each line represents the same cluster, with cluster themes on the far right.

Figure 7 reveals that China's "Five Metrics" research literature forms 13 clusters, with bibliometrics, scientometrics, informetrics, and webometrics appearing in cluster names. The knowledgometrics node lies within the informetrics cluster, not yet forming an independent cluster. Bibliometrics (including bibliometric) and scientometrics nodes appear earliest. Node sizes correspond to publication distributions, with bibliometrics as the foundation and starting point of "Five Metrics" research. Its node has dense connections with important nodes such as citation analysis, impact factor, core journals, and other "Five Metrics" nodes, indicating high co-occurrence relationships. Although knowledgometrics forms a cluster, its co-occurrence relationships show close connections with knowledge mapping, visualization, and knowledge management, representing one of the current research hotspots in "Five Metrics." Additionally, the big data node appearing around 2015 indicates that research combining "Five Metrics" with big data in the new data environment has become an inevitable trend. Nodes increase significantly over time, demonstrating the continuous enrichment and development of the "Five Metrics" system.

4. Discussion

4.1 Significantly Enhanced Influence of China's "Five Metrics" Research

The initial stage of China's "bibliometrics" research focused on translating, introducing, and validating foreign metrics research results, lacking independent systematic research. Following bibliometrics 启蒙 education in the 1980s, China's "Five Metrics" themed publications have shown a year-by-year upward trend. Research content is no longer limited to introducing foreign research frontiers, with domestic application, theoretical discussion, and methodological research replacing review studies as the mainstream. Particularly in the 1990s, the emergence of project funding for "Five Metrics" related research signified that Chinese scholars began comprehensive systematic research on "Five Metrics."

4.2 Prominent Interdisciplinary Characteristics of China's "Five Metrics" Research

From the concepts related to each "Five Metrics" branch and existing literature, all branches of the "Five Metrics" theoretical system have strong applicability. Their research requires support from mathematical statistics and computer technology, giving "Five Metrics" excellent interdisciplinary qualities, specifically manifested in cross-disciplinary research with mathematics, statistics, computer science, medicine, chemistry, biology, etc. Among these, mathematics, statistics, and computer science are mainly integrated at the methodological and technical levels. Mathematics and statistics methods have been core to metrics since bibliometrics' inception, becoming the original driving force for methodological innovation in "Five Metrics." The advancement of information technology and big data environment demands make "Five Metrics" development inseparable from computer technology support. The integration of computer science and "Five Metrics" has become key to practical "Five Metrics" research in the big data environment. Secondly, "Five Metrics" functions in identifying core journals, revealing research frontiers, and determining core authors have been applied in medicine, chemistry, physics, biology, and other disciplines.

4.3 Expanded Breadth of Research Objects in China's "Five Metrics"

Traditional "Five Metrics" measurement objects were paper-based academic literature resources. With information technology advancement and changes in scientific communication methods, the dissemination forms of academic literature resources have been revolutionized. Traditional card-based measurement methods have long been replaced by databases, which bring great convenience to bibliometric work. The surge in scientific literature data volume and diversification of science communication data types in the big data environment have, on one hand, promoted growth in measurement capacity for data volume and types. On the other hand, the development of new scientific communication forms such as open access journals and scientific blogs has expanded "Five Metrics" research objects from literature to scientific activities, information, and knowledge, promoting the development of webometrics, altmetrics, knowledgometrics, and other "Five Metrics" branches.

4.4 Fine-Grained Differentiation of Research Content in China's "Five Metrics"

In the big data environment, the data science-driven scientific research paradigm is closely related to data structure and information science technology. The encoded, structured, and standardized forms of academic resource dissemination provide data-level feasibility for fine-grained metric analysis such as data mining, sentiment analysis, citation content analysis, and knowledge discovery. The continuous refinement of measurement units fully excavates the knowledge value of scientific communication activities.

4.5 Continuously Enriched Technical Support for China's "Five Metrics" Research

Issues such as Chinese text synonyms, Chinese word segmentation, and polysemy create difficulties for Chinese literature metric analysis. Foreign mature literature information analysis units and visualization tools have poor processing effects and compatibility with Chinese texts and databases. To address these problems, Chinese scholars have developed multiple data analysis tools, providing convenience for domestic "Five Metrics" research. Meanwhile, mainstream metrics research software such as CiteSpace, VOSviewer, and BibExcel are also improving their compatibility with Chinese database data.

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Note: Figure translations are in progress. See original paper for figures.