A Visualized Analysis of Scientific Research Evaluation in Colleges and Universities Based on the Scientific Knowledge Mapping

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Abstract. Scientific research evaluation is the baton of scientific and technological innovation. Researches mostly focus on visualized analysis of scientific research management, and lack of visualized analysis of scientific evaluation in colleges and universities. Based on the knowledge mapping visualized analysis of CiteSpace and statistical analysis methods, a quantitative analysis is conducted on the research of core journals, CSSCI and CSCD in CNKI about scientific research evaluation in colleges and universities from January 1992 to July 2023. In order to promote innovation and development in subsequent research, the main force, hot spots and trends of scientific research evaluation in colleges and universities is firstly explored and then we form a holistic understanding about scientific research evaluation in colleges and universities. In this paper, we also find that performance appraisal, indicator system and evaluation system are the hot spots, research on scientific evaluation is becoming increasingly refined and scientific.

Keywords: Scientific research evaluation; Knowledge mapping; Research hot spots; CiteSpace

1 Introduction

The 20th National Congress of the Communist Party of China made strategic arrangements for the improvement of the scientific and technological innovation system and mechanism. Colleges and universities, as the main force of basic research, the source of core technology breakthroughs, and the main battlefield for talent cultivation, are important force for scientific and technological progress and social development in China. Organized scientific research is an important form of institutional and systematic service for national and regional strategic needs in scientific and technological in-

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novation of colleges and universities [1]. The core competitiveness of national scientific and technological innovation is essentially the scientific and technological innovation ability of colleges and universities. Scientific research evaluation is the baton of technological innovation. For the country, scientific research evaluation can achieve the rational allocation of scientific research resources, promote the priority development of key research fields, and catalyze the social application of scientific research achievements [2]. For colleges and universities, scientific research evaluation is the main means of scientific research management, which requires the application of scientific evaluation theories and methods, the adoption of appropriate evaluation scales, and the recognition of the impact and value of scientific and technological activities and their outputs. It is an evaluation and estimation of scientific and technological activities and effects [3]. In the new period policies for the reform of education evaluation and scientific and technological system and mechanism have been successively introduced. The scientific research evaluation orientation that follows the objective laws of scientific research innovation and talent cultivation is crucial for stimulating the enthusiasm of scientific researchers and improving the overall efficiency of scientific research innovation.

Over the years, how can colleges and universities play a guiding role and improve the efficiency of management services, stimulate the vitality of scientific research innovation, researchers have explored and pondered. Knowledge mapping is used to describe the changes of human knowledge resources and their carriers over time, and draw a knowledge graph, which plays an important role in mining, analyzing and displaying scientific and technological knowledge and interrelationships [4]. But researches mostly focus on visual analysis of scientific research management in colleges and universities, and lack of visual analysis of scientific research evaluation. Therefore, this article intends to systematically summarize the research status of scientific research evaluation in colleges and universities, present the current development status, research subjects, research hot spots, and development trends of this research field by using CiteSpace visual analysis tool, and provide some reference for theoretical research and practical exploration by research management departments and scholars in colleges and universities.

2 Data and research method

The data we used in this paper were collected from core journals, CSSCI and CSCD in CNKI database about scientific research evaluation in colleges and universities. The search time frame was set from January 1992 to July 2023, the retrieval time was 15th July 2023. The retrieval keywords consisted of two parts, one part included the keywords as “scientific research evaluation” “scientific and technology evaluation” “research assessment” “research management evaluation” “technology assessment” “technology management evaluation”; the other part included the keywords as “colleges and universities” “colleges” “universities” “scientific research institution” “educational institutions” “institutions of higher learning”. After searching, a total of 1025 pieces of data was obtained by excluding duplicate records, book reviews, related introduction

and news etc. Then, quantitative statistical analysis was conducted using literature visualized tool Citespace 6.2.R3, such as publication volume, author, organization, and keywords. In order to promote innovation and development in subsequent research, we mainly firstly do the research by displaying the research power, main topics and trends by scientific knowledge mapping, and present these existing research results. Then we can form a holistic understanding about scientific research evaluation in Chinese colleges and universities.

3 Development of scientific research evaluation in colleges and universities

3.1 Annual number of publications

The annual number of publications reflects the changes in the hot spots and main topics of scientific research evaluation in colleges and universities. As shown in Figure 1, annual number of publications present a growing situation. In recent years, in order to meet the need of national economic development and social progress, scientific technology development has made progress by leaps and bounds. With the continuous deepening of the reform of high education and technology systems and mechanisms, annual number of publications about scientific research in colleges and universities have made a huge step forward along with. The annual number of publications can be summed up in four phases. From 1992 to 2002, the overall number of publications is relatively small and growing sluggishly, the highest annual number of publications is less than 10 pieces, indicating that the research receives little attention. From 2003 to 2007, the annual number of publications double, up to about 20 pieces, demonstrating that the research has attracted attention and recognition from scholars. From 2008 to 2017, the annual number of publications achieves rapid growth and reaches two peaks, up to 77 pieces. It means that the research on scientific research evaluation have attracted more and more attention from scholars and become more mature. From 2018 to present, the annual publication number decreases, maintaining around 55 publications, it means that the scientific research evaluation enters a stage of steady growth.

Fig. 1. Annual number of publications about scientific research in colleges and universities

3.2 Institutional contribution statistics

After data analysis, 273 institutions were obtained. It can be divided into two categories, one is professional institutions, as Ministry of Education, Ministry of Science and Technology, National Natural Science Foundation of China, Provincial Department of Science and Technology, provincial department of public education, China Center for Scientific Evaluation and Research, science and technology strategy consulting and research institute and research management departments. Their research further promotes the integration of theoretical research and scientific research management practices, which has important guiding significance for the theoretical development of scientific research evaluation. The other is related institutions, as libraries, editorial department of university journals, and other branch units. They conduct specific research and analysis from different disciplines and perspectives. As shown in Figure 2, there are 18 institutions which total number of publications is more than 9 pieces. The top three institutions are Chinese Academy of Sciences, Shanghai Jiao Tong University and Nanjing University, the quantities are 24, 20 and 19 respectively. These universities not only have strong scientific research capabilities, but also attach great importance to research on scientific research evaluation.

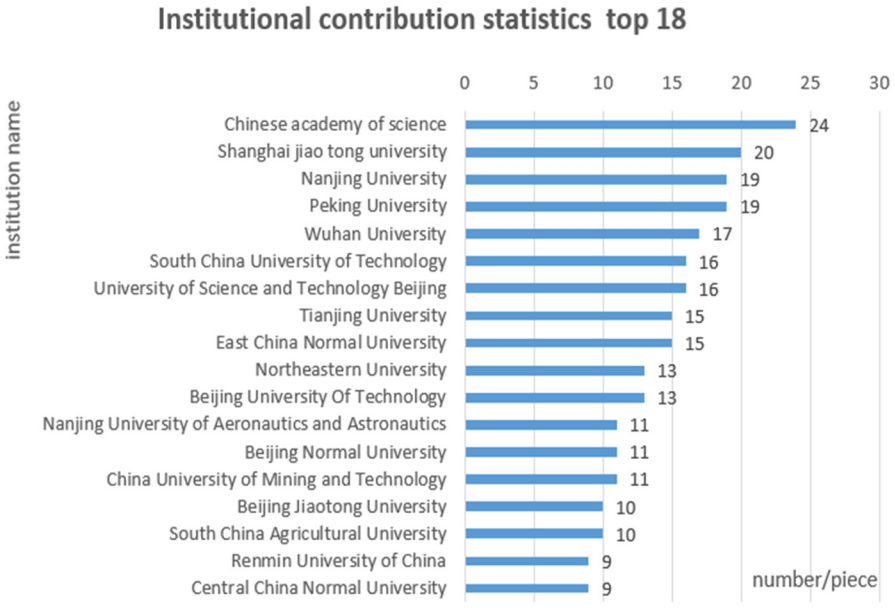

Fig. 2. Institutional contribution statistics about scientific research evaluation in colleges and universities top 18

4 Analysis of research hot spots in scientific research evaluation

4.1 High-frequency keywords analysis

The keyword is a highly condensed understanding of the research content, academic ideas, and viewpoints of the research. In the keywords co-occurrence graph, the frequency and centrality of keyword occurrences are positively correlated with the degree of common concern among scholars. Therefore, high-frequency and highly central keywords represent research hot spots in this field, the higher the frequency and centrality, the more important the node is in this field [5]. In view of this, high-frequency keywords can be used to explore and study the basic principles, research hot spots, and the development process and characteristics of this field can be horizontal and vertical analysis. The keywords co-occurrence graph consists of 542 nodes and 1063 connections, displaying the characteristics of dense nodes and tight connections. It can be seen that the research topics of scientific evaluation are relatively concentrated and have strong extensibility. Multiple topics are extended around each high-frequency keywords as the center, and the research relationship between them is close. Centrality is also an important indicator for analyzing the importance of keyword, if the centrality is greater than 0.1, it indicates that the node is an important and influential central node in the research. Based on the data on centrality, we can find no evident relevance between frequency and centrality. Removed duplicates or search term keywords, and merged approximate words, from the analysis of keyword centrality and keyword frequency, the top four keywords are “performance appraisal” , “indicator system” , “evaluation system” and “scientific efficiency”, representing research hots pots and main directions for over 30 years.

4.2 Analysis of research hot spots

Based on high-frequency keywords analysis and interpretation of literature, the top three research hot spots of scientific research evaluation in colleges and universities are “performance appraisal”, “indicator system” and “evaluation system”.

First, performance appraisal of scientific research evaluation. Performance appraisal is an important part of scientific research evaluation. Scientific research performance evaluation is a scientific research management method and activity, which aims to serve the strategic goals and positioning of colleges and universities, enhance the competitiveness of scientific research, use scientific methods to conduct input-output comprehensive performance analysis of scientific research activities, reflect scientific research orientation, optimize the allocation of scientific research resources, and promote the development of scientific research in colleges and universities [6]. Scientific research in colleges and universities plays an increasingly important role in national scientific and technological innovation and promoting regional economic development, the national investment in college and university research is increasing along with. Scientific research achievement has become one of the important indicators for measuring the scientific research ability and comprehensive strength of colleges and universities, af-

fecting their position and ranking in higher education nationwide. Representative keywords include "performance appraisal", "research performance" and "scientific research efficiency". The research of domestic scholars mainly includes the following content. From the perspective of university, it can be divided into colleges and universities and subject. Colleges and universities include national universities (double first-class universities, 211-project universities), local universities, regional universities, specialty colleges and universities, and science park, research team etc. According to the subject classification, it includes humanities and natural science. In terms of research content, it includes research funds, project, laboratory, achievement transformation, input, output, indicator system, evaluation system, journals and electronic resources, performance and electronic resources. From the perspective of evaluation objects, it includes the theory (triple helix theory, improved interval value D-S theory, BSC and Grey fuzzy theory), policy system, mechanism, models, methods (AHP method and K-means clustering analysis, data envelopment analysis, adaptive analytic hierarchy process, FCE method) and practice. On country classification, it includes China, Britain and America etc.

Second, indicator system of scientific research evaluation. The construction of scientific research evaluation indicator system is the core of scientific research evaluation in colleges and universities. An objective, fair and scientific indicator system can more accurately reflect the quality and level of scientific research achievements. The research of domestic scholars mainly includes the following content. Researches on construction of indicator systems account for one-third of the total amount, including the evaluation of scientific research funding, projects, quality, innovation ability, project process. Following by indicator system of scientific research achievements, scientific research competitiveness, research environment, laboratory benefits, academic influence, personnel training, journal and website. These studies elucidate the research status, achievements, methods, existing problems, and optimization methods of domestic and foreign research evaluation indicator systems. Gu Ping believes that the evaluation indicator system for scientific research should consist of two parts: core indicators and expansion indicators, which can objectively, reasonably, and periodically evaluates colleges and universities of the same type but with different scientific research capabilities, and promotes the improvement of scientific research management and service levels. Tian jun believes that we should further refine and summarize the common key elements and professional key elements of these types of scientific research talent evaluation, then construct a scientific and technological talent evaluation index system which include six dimensions including innovative knowledge, moral quality, innovation motivation, influence, innovation ability and output performance. The indicator system has gradually gotten scientific and refine, tending towards innovation, quality and capability.

Third, evaluation system of scientific research evaluation. The scientific and technological evaluation system gradually changes into a high-quality one, it is a strong support for constructing a high-quality higher education system, and it extends and deepens the theoretical connotation of improving the scientific and technological innovation ability of high-quality national education [7]. Due to the late start of science evaluation in China, the evaluation system is still in the exploratory stage. The research

focus on the construction of external evaluation systems and the reform of internal incentive mechanisms. For example, PCA analysis method, comprehensive index method, 5E management method and AHP method etc, these research methods are be used to research and optimize mechanism, including scientific funding, projects, talents, platforms such as laboratories, scientific research competitiveness, scientific research management, innovation environment, think tanks, review the work quality of experts, journal and achievement transformation. Quantification of evaluation system, present situation, difficulties and suggestions also receive a lot of attention. In addition, scholars studies the international experience of scientific research evaluation systems in the UK, France, the US, the Netherlands, Japan, South Korea, and Australia in especial. To deal with the new requirements of the new era, full process innovation and high-quality transformation are the current keynotes.

5 Analysis of the evolution and development trends of scientific research evaluation hot spots

We draw a keywords co-occurrence time zone map of scientific research evaluation in colleges and universities by CiteSpace, the distribution changes of keywords demonstrate the evolution path of research hot spots in this field. From Figure 3, which shows the keyword occurrences burst history, it can be seen that the evolution of research hot spots in scientific research evaluation.

From 1992 to 2002, it is the initial stage of scientific research evaluation. The keywords focus on evaluation and scientific research, including the benefits of scientific research, evaluation system, outcome evaluation and quantitative evaluation. In 1997, the Science and Technology Evaluation Center of the Ministry of Science and Technology was established, which is the first national level science and technology evaluation agency of the Chinese government. It is responsible for providing evaluation, consultation, training, and investigation services for scientific and technology activities of the government, domestic and foreign enterprises. The scientific research evaluation in colleges and universities mainly revolves around research funding, evaluation indicators, scientific management and performance appraisal. These have gradually become the main research direction of scientific research management in colleges and universities.

From 2003 to 2017, this is the rapid development stage of scientific research evaluation. In 2003, “the Decision on Improving the Evaluation of Science and Technology” emphasized the need to standardize scientific and technological evaluation work and guide scientific and technological work developing towards a healthy direction [8]. State Council issued Outline of the National Medium-Term and Long-Term Science and Technology Development Plan, Strategic deployment to enhance independent innovation capabilities and would build an innovative country [9]. Some research hot spots have been sustained and further refined, just as scientific research ability, evaluation index, scientific research evaluation. At the same time, university teachers, H-index, performance appraisal, scientific efficiency, integration, innovation, evaluation

mechanism, method and incentives and academic evaluation are developed from multiple dimensions. With the country take more attention to scientific technological development and the development of educational reform, researches apply more theories and methods, more refined research content and subject classification. Evaluation system gradually forms. With the development of key discipline construction, high-level university construction and dual first-class university construction, scientific research evaluation has attracted more researchers. Meanwhile, more researcher results were produced. The theme is quality oriented and collaborative innovation.

From 2018 to present, the main theme of scientific research evaluation guides by innovation ability, quality, and contribution. Colleges and universities are advocated for organized scientific research. In May 2018, it was emphasized that we need to innovate the talent evaluation mechanism, establish and improve a technology talent evaluation system guided by innovation ability, quality, and contribution. So that we can form and implement an evaluation system, which is conducive to the dedicated research and innovation of technology talents.

In July 2018, the Central Committee of the Communist Party of China, the State Council announced that "Opinions on Deepening the Reform of Project Review, Talent Evaluation, and Institutional Evaluation" [10]. Promotion strategy, construction of index system, the construction of indicator systems, improvement of scientific research innovation capabilities, and efficiency, as well as the evaluation of achievements transformation, are hot topics of continuous attention.

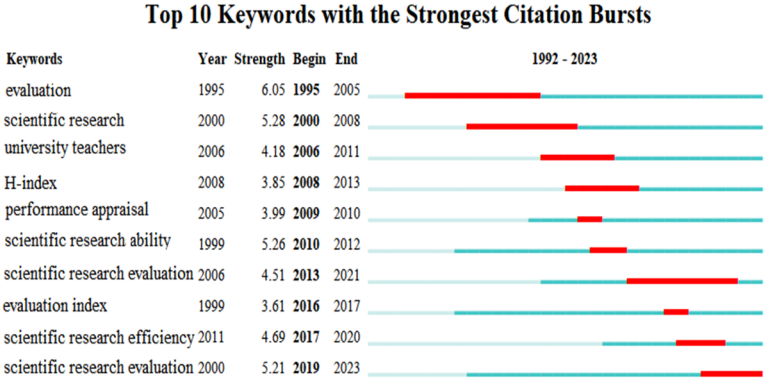

Fig. 3. Top 10 keywords with the strongest citation bursts about scientific research evaluation in colleges and universities

6 Conclusion

This study systematically analyzes the research status, hot spots, and evolution trends of scientific research evaluation using the knowledge mapping visualization and statistical analysis methods. The major conclusions are taken as follows: (1) The research on scientific research evaluation covers the initial development phase, the blowout growth phase, and the publications demonstrates a trend of continuous growth on the whole.

(2) The research characteristics in this field are diverse, and research hot spots are also widely distributed, showing outstanding interdisciplinary and refined characteristics.

Given that scientific research evaluation is closely related to national research policies, under the background of building a road leading to technical powerful nation, scientific evaluation and innovation are complementary to each other is an important content and well worth studying in the future. Collaborative innovation and organized research need to advocate multidimensional dynamics evaluation and form a scientific and comprehensive research evaluation system. Moreover, it is necessary to design a more reasonable indicator system which can objectively evaluate and stimulate the scientific research potential of talents, and further promote it for comprehensively evaluating the innovation quality of scientific achievements. In response to the characteristics of valuing the short term over the long term in scientific evaluation, the research issues how to deepen organized scientific research management, create competitive innovative elements, build a full process innovation ecosystem, and strengthen the construction of cultivation mechanisms and long-term planning and design needs to be further explored in the future.

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