

Status and Trend of Research on the Funding and Management of Basic Research in China

An Analysis Based on Knowledge Maps of Core Journal Database of China National Knowledge Infrastructure in 1992-2019

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Yang Yang ^(✉), Xiangyu Zhu
Beijing University of Technology, Beijing, China
18351989082@163.com

Abstract—This paper aims to clarify the current status, hotspots, historical evolution and development trend of the research on funding and management of basic research in China. Firstly, 736 relevant papers indexed during 1992-2019 in the core journal database of China National Knowledge Infrastructure (CNKI) were analyzed in details. Using the information visualization software CiteSpaceV5.6.R3, the institutional cooperation co-occurrence map, author cooperation co-occurrence map, keyword co-occurrence map, and keyword timeline view maps were plotted through content mining. The results show that: the research institutions in the research field of basic research funding and management have formed three core cooperation networks, and the institutions in Beijing attract the most attention; most of the prolific and active authors choose teamwork over independent research; the research topics mainly fall into four aspects of basic research: input, subjects, results, and talents; the research hotspots are in line with policies and demands, and evolve through three stages: exploration and gradual progress, adjustment and development, and expansion and acceleration. The research results open up a new direction for relevant studies, and provide a reference for innovative parties to implement basic research.

Keywords—Basic research, knowledge map, current status, hotspot, trend

1 Introduction

At present, a new round of scientific and technological revolution is on the march, and the industrial revolution is developing rapidly on a large scale, meanwhile, the basic research is exploring into new scopes and depth [1-3]. With the rapid progress of the Open Science Movement and the World Science Initiative, new scientific research methods and tools are developing rapidly, the paradigm of scientific research is undergoing new changes, and the research in basic science (namely the basic research) has become the crux to promoting innovation [4-7]. The competition between countries has slowly moved into the field of basic research, and basic research has

occupied an increasingly prominent position in the world countries' strategic resources [8-11]. Now, countries around the globe are emphasizing that basic research activities should serve the needs of the nation, and they are making great efforts to pursue original innovation so as to ensure the country's leading position in the scientific field [12-15].

In China, currently there are still situations such as the investment in basic research is insufficient, a diversified investment mechanism has not been formed yet, the quality of research achievements needs to be improved, and there's few original or preliminary research, etc., and these problems are closely related to the basic research funding and management. Now, some scholars have realized the said problems and conducted discussions on basic research funding and management from multiple perspectives such as the money of the funds, result evaluation, and talent management, etc., however, no one has summarized these valuable results.

In view of this, in this paper, relevant literatures concerning the issue of basic research funding and management indexed in the core journal database of CNKI from 1992 to 2019 were selected as research objects, and the current status, hotspots, historical evolution and development trend of the research on basic research funding and management were analyzed, summarized and plotted into knowledge maps using CiteSpaceV5.6.R3. This paper aims to provide a reference for China's basic research to seize opportunities, cope with challenges, and find future directions.

2 Data Source and Processing

2.1 Data source

In 1992, the concept of National Innovation System was introduced in China for the first time. Since then, the number of searches of relevant literatures grew fast and the number of relevant literatures increased significantly. Given the time lag of policies and the distribution of literatures, this paper selected the core journal database of CNKI to search for relevant literatures from 1992 to 2019. CNKI has a large number of literatures, it comprehensively covers all research subjects, and can basically reflect the research situations of basic research funding and management in China.

2.2 Search strategy

Literatures with basic research as the subject were searched in the database, then within the search results, literatures discussing basic research funding and management were manually screened and selected. The specific search operations were: in the advanced search page of CNKI, the search method was search by document subject (subject=basic research), the time interval was set from 1992 to 2019, the "source category" was "core database", then, a total of 11,457 search results were obtained. Considering there are multiple expressions for basic research, with "basic science research", "science fund", and "scientific research" as the search word, the search was conducted again, and obtained 1,233, 8,904 and 42,714 search results, respectively.

2.3 Screen strategy

Literatures in the above search results were mostly papers from specific research fields such as biology, medicine, and agriculture, and they were mostly introductions about basic research progress in their respective field. Since the research objects of this paper were scholars' opinions on the essential characteristics, funding and management of basic research, the search results need to be screened again. First, by comparing the title and text, repeated results were removed; then search results such as reports, meeting notices, documents, instructions for authors, and journal preface were deleted as well; after that, literatures that didn't talk about the essential characteristics, funding and management of basic research, or not that relevant were screened out; at last, a total of 736 academic papers were obtained as valid search results.

3 Characteristic Analysis of Research Papers

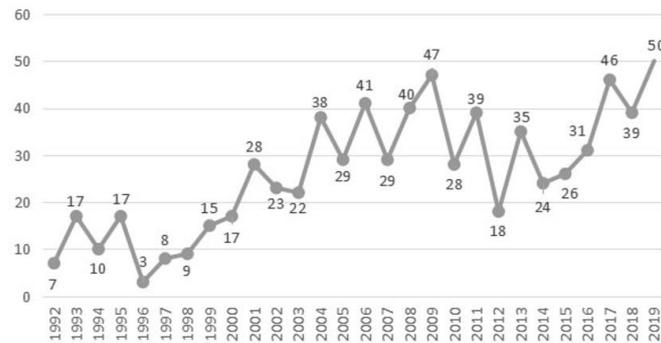


Fig. 1. Number of published papers concerning basic research funding and management each year

The number of published research papers concerning basic research funding and management showed an increase trend, and the papers were distributed in stages. Year 1998 and year 2012 were two obvious turning points (see Figure 1). 1992-1997 was the initial stage, the number of papers was not much, and the progress of related research was slow. Since 1985, China established the National Natural Science Foundation; Spark Program, 863 Program, 973 Program and other science programs, the basic research funding and management mode began to take shape. From 1998 to 2011, the number of published papers grew fast and steady, and during this time period, China proposed the national innovation system, emphasizing independent innovation and aiming to build China as an innovative country; meanwhile, the Department of Basic Research was established under the Ministry of Science and Technology of China, and basic research funding and management works had been improved constantly. From 2012 to 2019, the number of published papers continued to grow, and the work focus of this time period was to implement the innovation-driven development strategy and build China as a world power in science and technology. At the same time, the Party Central Committee of China attached great importance to the

reform of the scientific and technological system and promoted the academic research on basic research funding and management.

4 Research Institutions and Authors

4.1 Cooperation of research institutions

In general, there are many research institutions in the field of basic research funding and management, but the connectivity is low. In CiteSpaceV5.6.R3, with “Institution” selected as the network node, the program was run and a knowledge map of field research institution cooperation network (see Figure 2) was generated. In the figure, there're 300 network nodes, 167 network connections, and the network density is 0.0037. This means that although there are many research institutions in the field of basic research funding and management in China, these institutions are not closely connected, the connectivity of the cooperation network is low, and the research is scattered.

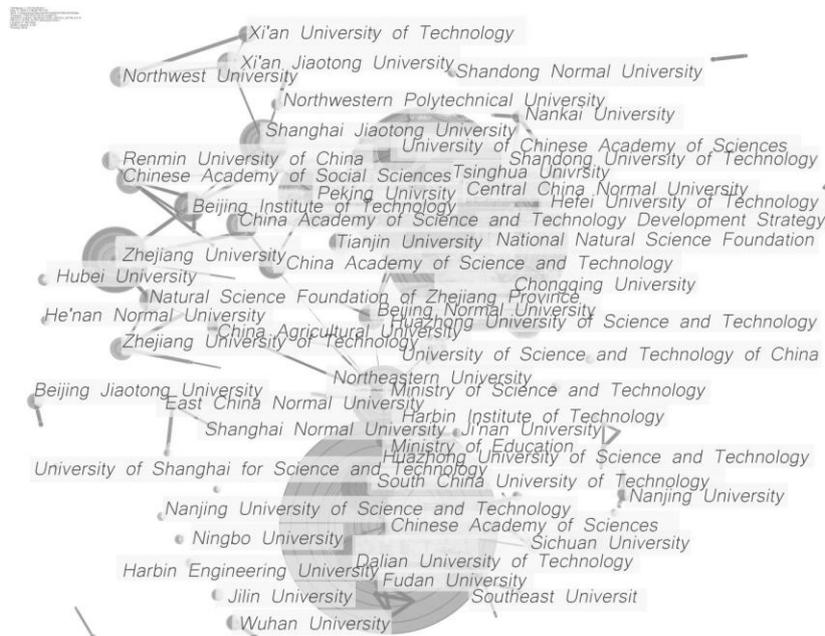


Fig. 2. Research institution cooperation network knowledge map

In terms of institutional cooperation, there are three core cooperation networks. The internal structure of a cooperation network is relatively close, the cooperation is mostly local cooperation, and higher educational schools and scientific research institutes are the main force. The cooperation network in Beijing region is the most prominent one, showing characteristics such as high network density and wide radiation

range. In addition, most cooperation in this field is between research institutes and colleges and universities, the research power in industries is relatively weak, which requires to form the new pattern called the industry-university-research collaboration. At the same time, cross-regional cooperative research still needs to be further deepened, and connections between different cooperation networks need to be strengthened.

4.2 Cooperation of authors



Fig. 3. Author cooperation network knowledge map

Research authors are scattered throughout, and there are many prolific authors. In CiteSpaceV5.6.R3, with “Author” selected as the network node, the program was run and a knowledge map of field research author cooperation network was generated (see Figure 3). In the figure, there are 1123 network nodes, 1048 network connections, and the network density is 0.0017. Further, the number of published papers written by these authors were counted, according to Professor Price's theory about outstanding scientists, there are 65 core authors who have published 3 or more papers. Statistics show that, in the research field of basic research funding and management, there are many prolific authors and they are quite active, but their connections are not close.

There is an obvious cooperation network among prolific authors. According to Figure 3, the analysis on the node size and connecting line thickness show that, larger collaboration teams in this field include Chen Jin, Zeng Guoping, Han Yu, Wu Shanchao and others' teams. Obviously, authors in these collaboration teams generally publish more papers, the cooperative relationships among team members are closer. In addition, in terms of the author's institution, most of the core authors with 3 or

more published papers are from Zhejiang University, Tsinghua University, National Natural Science Foundation of China, University of Chinese Academy of Sciences, and other influential institutions. Moreover, we can also see that these collaboration teams mostly have cross-institutional cooperative relationships, and the knowledge flow among scholars has been strengthened.

5 Subject Changes

Keywords reflect the research focus of scholars. The statistical analysis of keywords in a certain research field and the observation of keyword evolution will help us quickly figure out the research hotspots and frontier trends in this field [16]. To this end, keyword co-occurrence analysis and timeline map analysis were carried out in stages to identify the evolution and changes in the field.

5.1 Keyword co-occurrence analysis of basic research funding and management



Fig. 4. Keyword co-occurrence knowledge map of 1992-1997

CiteSpaceV5.6.R3 was run with "Keyword" set as the node type to generate the keyword knowledge maps of 1992-1997, 1998-2011, and 2012-2019 (see Figure 4, Figure 5, Figure 6):

1. Exploration and gradual progress (1992-1997)

At this stage, high-frequency keywords of relevant papers mainly include: basic research, basic applied research, scientific research, National Natural Science Foundation, basic scientific research, funding investment, and financial management, etc. It can be seen that the early studies concerning basic research funding and management mainly focus on the analysis and discussion of the concept, connotation, and characteristics of basic research. In addition, since the guiding ideology of scientific and technological works in a long period of time before 1995 was that "scientific and technological works must be oriented towards economic construction", during this period, economy-related keywords such as gross national product and financial management appeared more often.

2. Adjustment and development (1998-2011)

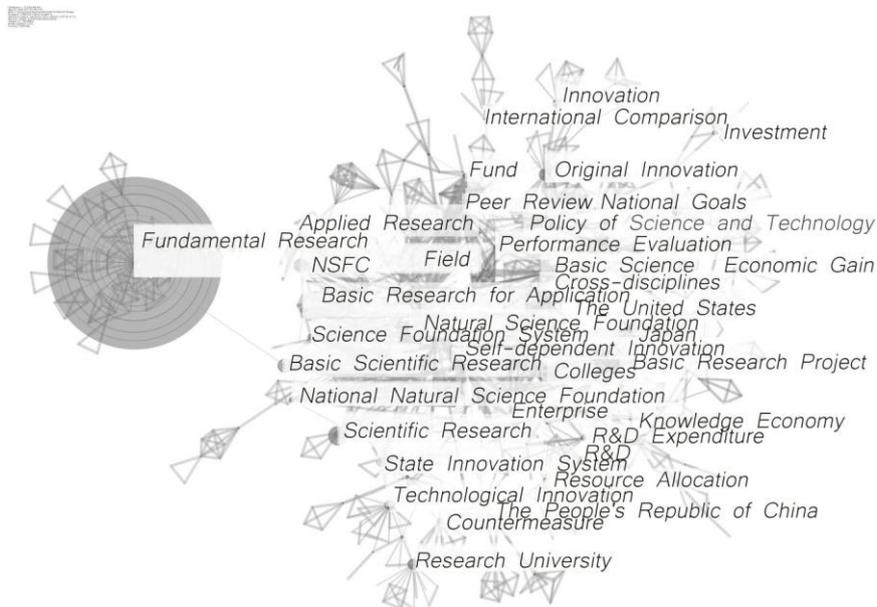


Fig. 5. Keyword co-occurrence knowledge map of 1998-2011

At this stage, high frequency keywords of relevant papers mainly include: national innovation system, knowledge economy, science and technology policy, research university, science and technology innovation, independent innovation, and science funding system. It can be seen that the studies concerning basic research funding and management had gradually deepened in this period, and they strengthened their connections with practical applications and national policies. This period is an important turning point for China's basic research works, since then, China has greatly strengthened the supports for the development of basic research from aspects of policies, science plans, and financial investments. For example, in the *Outline of the National*

Medium and Long-term Science and Technology Development Program (2006-2020) released in 2006, China had proposed the independent innovation strategy, which had affirmed the role of basic research in promoting knowledge growth, cultivating creative talents, developing high and new technology, and building advanced culture; therefore, the keyword “independent innovation” had appeared more often.

3. Expansion and acceleration (2012-2019)

As related research continued to increase, the research topics had expanded to science and technology power, innovation-driven, scientific and technological system reform, and basic research policies. At this stage, the keywords are all closely related to China’s science and technology policies and the actual needs. In 2012, *Opinions on Deepening the Reform of the Science and Technology System and Accelerating the Construction of the National Innovation System* put forward the requirement of “accelerating the construction of national innovation system”. The National Innovation-Driven Development Strategy Program release in 2016 had proposed the goals of “joining in the ranks of innovative countries”, “becoming a top innovative countries” and “building China as a science and technology power” with 2020, 2030 and 2050 as the time nodes. In 2019, the Fourth Plenary Session of the 19th Central Committee of the Party had pointed out that it is necessary to improve the scientific and technological innovation mechanism and accelerate to build China into an innovative country.

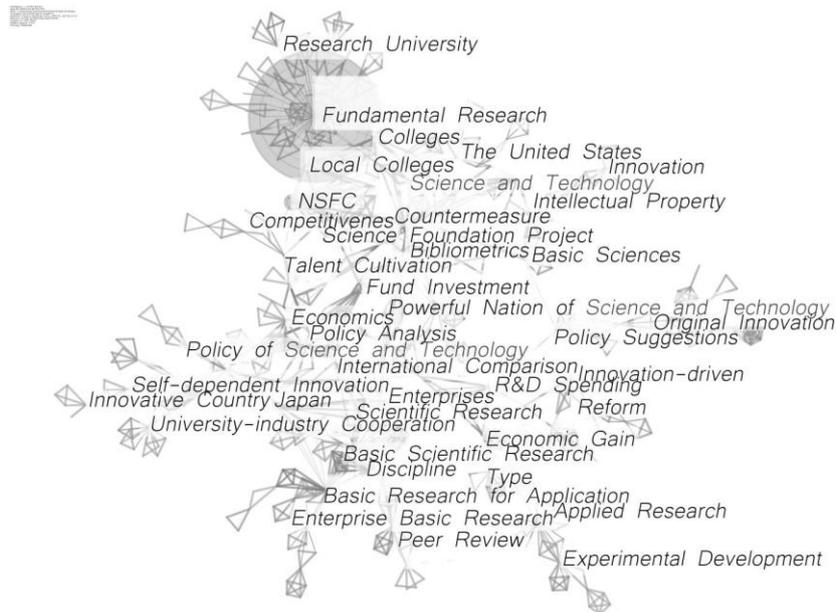


Fig. 6. Keyword co-occurrence knowledge map of 2012-2019

5.2 Timeline view analysis of keywords in the research field of basic research funding and management



Fig. 7. Keyword timeline view map of 1992-1997

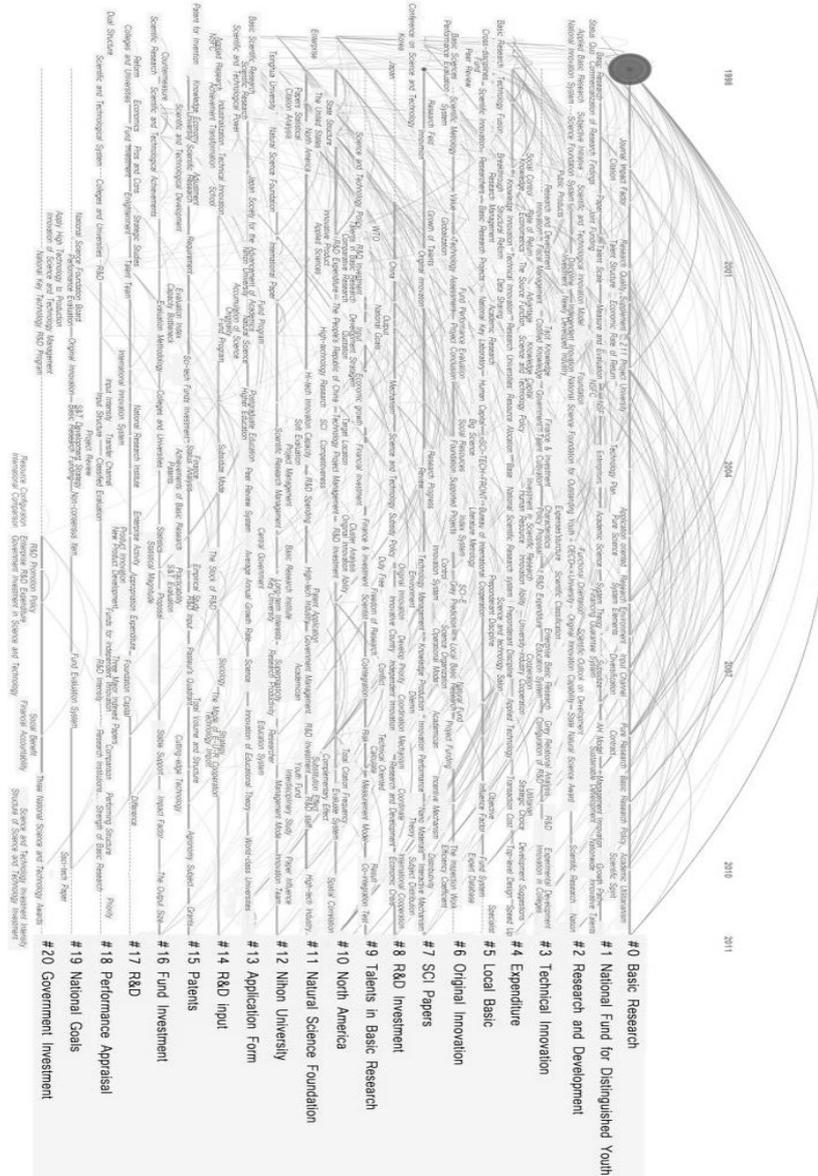


Fig. 8. Keyword timeline view map of 1998–2011

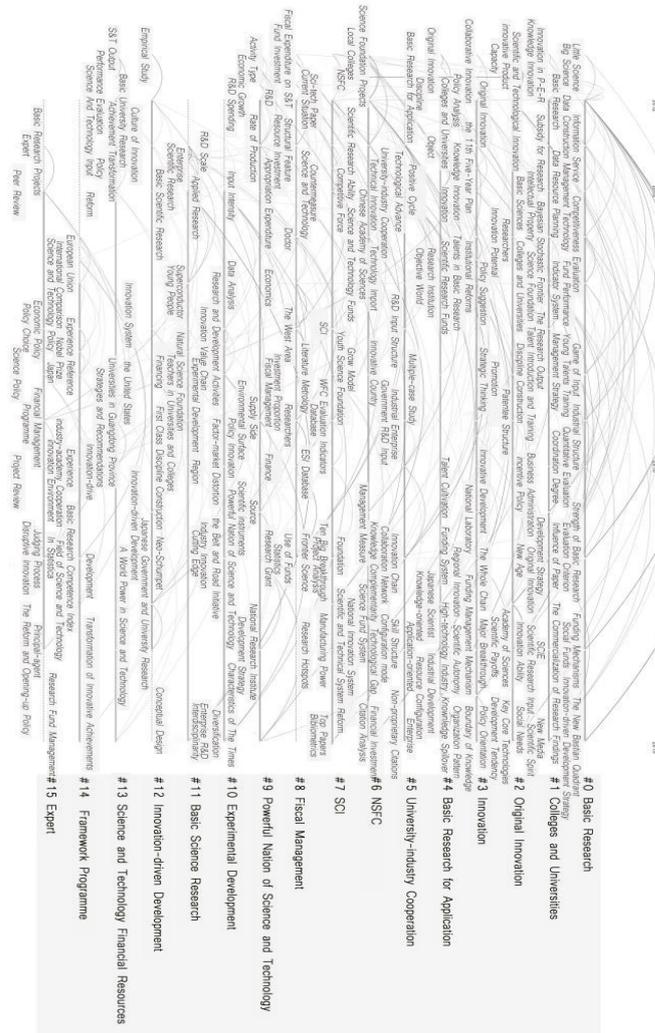


Fig. 9. Keyword timeline view map of 2012-2019

Based on above keyword knowledge maps, in order to more clearly reflect the evolution of research hotspots and the main knowledge subgroups in the research field of basic research funding and management, the view maps were selected as timeline view maps according to the generated keyword knowledge maps, then the keyword timeline view maps of 1992-1997, 1998-2011, 2012-2019 were obtained as shown in Figure 7, Figure 8, and Figure 9. In the figures, each node represents a keyword. The more keywords on the horizontal lines, the more important the clustering field obtained, from the figures, we can also observe the rise and fall of particular clusters [17].

After reviewing the cluster generation reports of the three stages, the clusters were divided into four aspects: input, subjects, results, and talents. In terms of basic research input, the research focuses of scholars are mainly funding sources, funding methods, and intensity and structure of investment; in terms of research subjects, the keywords “National Natural Science Foundation”, “colleges and universities”, and “enterprises” appeared in all three stages; in terms of results, scholars not only pay attention to the “direct” research results of basic research, such as academic papers, but also discuss the far-reaching impact of basic research, such as economic growth and innovation; in terms of basic research talents, high frequency keywords including “academic leader”, “National Science Fund for Distinguished Young Scholars”, and “experts” show that, the cultivation of basic research talents (especially top talents) has always been an urgent problem to be solved.

6 Conclusions and Prospects

6.1 Research conclusions

This paper used CiteSpace to systematically analyze the research power, research hotspots, and research trends of relevant research literatures in the field of basic research funding and management in China. The results are as follows:

1. In terms of research institutions, generally their distribution shows the pattern of “small clusters and scattered majorities”. Judging from the current research institutions, colleges, universities and research institutes in Beijing have prominent influence in the research field of basic research funding and management and their cooperation is closer, and most of these higher educational schools are key national universities. In addition, the National Natural Science Foundation of China and the Chinese Academy of Sciences are playing very important roles in the said research field, and they have made great contributions in research paper publishing and research program cooperation. In terms of authors, statistics show that prolific authors in the target field are more active, and there are obvious cooperation networks among them, these prolific authors are mostly from influential universities and research institutions.
2. In terms of research subjects, generally the subjects focus on four aspects of basic research, namely input, subjects, results, and talents. Papers concerning research input mainly discuss the funding resources, funding methods and investment intensity of basic research from the perspectives of basic research funding and subsidizing, national financial management, and resource allocation for scientific and technological investment. Research papers concerning research subjects emphasize on the industry-university-research cooperation, high frequency keywords of these papers include: National Natural Science Foundation, colleges and universities, and enterprises. Papers concerning research results mainly focus on the important role of basic research in promoting technological innovation, economic growth, and knowledge innovation, and the discussions on the evaluation of basic research re-

sults are deepening as well. Papers concerning research talents mainly explore the problems existing in the team construction of basic research works, and the effective ways to cultivate talents for basic research works.

3. In terms of research hotspots, relevant studies show that research hotspots have obvious policy orientation and phased distribution characteristics. The evolution of research hotspots went through three stages: exploration and gradual progress stage (1992-1998), papers in this period mainly focus on the concept, connotation and characteristics of basic research; adjustment and development stage (1998-2012), at this stage, the research on basic research funding and management had deepened gradually, and papers in this period mainly talk about knowledge economy, research universities, independent innovation, R&D funding, and strengthening the connections with practical applications and national policies; expansion and acceleration stage (2012-2019), at this stage, related research continued to increase, and the research focus further expanded, papers in this period mainly focus on topics such as original innovation, innovation-driven, and building China into a science and technology power; the research had gone into a deeper level.

6.2 Prospects

With the changing international situation and advancing national strategies, in China, the development of basic research is facing new opportunities and challenges, bringing new questions and topics for relevant research works. The following aspects can be further studied in the future:

1. How to effectively cope with new situations and challenges in basic research. As a new round of scientific and technological revolution is on the rise, the paradigm of scientific research is undergoing profound changes, the international system and order are adjusting, and the global governance system is developing at a high speed. Major western countries have adopted corresponding measures to cope with the new situations. For example, the United States reformed the National Science Foundation and renamed it as the National Science and Technology Foundation, aiming to promote the close connections among "science", "technology" and "innovation". The UK Research Council has been reorganized into the new UK Research and Innovation Agency, targeting at establishing a research and innovation system that can meet future challenges from the aspects of environment, society, and economy. Therefore, in the future, basic research works should face the major national demands and target at the economic field, efforts should be made to perfect the mechanism of summing up the science of core technologies, and the mechanism of cultivating major original achievements; also, future research should try to enhance the enthusiasm of enterprises in basic research, and build diversified research investment mechanisms to deal with the various uncertainties brought about by the changes in the international situations; moreover, future research could also discuss issues such as the development of basic research under the guidance of the Sustainable Development Goals proposed by the United Nations.

2. How to strengthen the exchanges of various research institutions. The cooperation maps told us the research institutions have not formed solid cooperation centers yet, there's few basic research institutions, and there's few researchers participating in basic research outside universities and research institutions, and this is not conducive to the development of basic research and academic communication. Therefore, it is necessary to build a scientific research network involving multiple parties such as government, colleges and universities, research institutions, and enterprises, so as to encourage learning exchanges between domestic and foreign scholars, and promote collaborative cooperation between research institutions. By establishing exchange platforms for these different parties, we could promote the sharing of academic resources and expand knowledge fields, thereby effectively raising the research level and increasing high quality research outcomes.
3. How to quantify research results and provide scientific data support. Although China's research efforts in the field of basic research funding and management have been enhancing since the reform and opening up, most of the existing researches still use the traditional qualitative analysis and case analysis methods, there's few empirical analyses using quantitative methods or based on data, thus it's difficult to accurately analyze the development status of basic research. The unquantifiable qualitative research is not conducive to proposing specific and operable improvement strategies, and thereby hindering the knowledge accumulation and research breakthrough. One thing worth mentioning is that the era of big data has provided a good opportunity for quantitative research in the field of basic research funding and management. Important internal factors for the development of basic research may be hidden behind the big data, and future research could focus on mining the value of these data.
4. How to further internalize and integrate foreign basic research theories and practice. Currently, there's a few domestic research papers concerning the experience of foreign developed countries in the field of basic research funding and management, especially US and Japan, however, most of these papers are simple descriptions or comments. Actually, there are huge differences in the economy systems and social patterns of China, US, Japan, and other countries, and simply coping their development experience may cause inadaptation to the development of China's basic research. Only by analyzing and summarizing the essential characteristics and laws of the development of basic research in developed countries and combining with the characteristics and status of China's basic research can we develop basic research experiences and theoretical systems with the Chinese characteristics.

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9 Authors

Yang Yang, female, born in Yancheng, Jiangsu Province, master candidate of School of Economics and Management, Beijing University of Technology, Beijing 100124, China. Email: 18351989082@163.com

Xiangyu Zhu, male, born in Shenyang, Liaoning Province, associate professor, Ph.D., School of Economics and Management, Beijing University of Technology. Email: zhuxiangyu221@126.com

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