



## INNOVATIVE ANALYSIS OF THE RESEARCH OUTCOME IN PRIVATE UNIVERSITIES BASED ON MAPPING KNOWLEDGE DOMAINS

Meng Zhang, Minte Fan  
International College, Krirk University, Bangkok 10220, Thailand,  
24238266@qq.com

### Abstract

This paper took public universities as the benchmark, conducted a study on the literature involved scientific research work in private universities utilizing the bibliometric method of mapping knowledge domains. The objective is to analyze the scientific research situation in private universities and explore scholars' concerns about it, as well as reveal the weaknesses of the work and the differences and gaps between private and public universities. The research ideas, literature retrieval methods, operation steps of mapping knowledge domains, analysis process, and analysis conclusions were introduced. The problems are found through the statistics over the number of papers and research by keywords cluster graph and keywords time graph. These problems included in private universities are: the research work lacks innovation drive, the level of talent cultivation requires improvement, the research work lacks internal drive, the influence of central financial expenditure on scientific research has a hysteresis quality but the correlation is high. It is suggested to establish a thorough scientific research management system to ensure the smooth development of scientific research work, meanwhile, establishing a talent training mechanism of production-learning-research integration to improve the level of scientific research personnel. Thus, the level and effectiveness of scientific research work in private universities can be improved.

Keywords: private universities, scientific research, mapping knowledge domains, bibliometric method

### Introduction

Private universities refer to the higher education schools and other educa-

tional institutions organized by enterprises, social organizations or citizens using private funds. After 40 years of development, private universities in China have become an important part

of higher education and have made significant contributions to higher education (Rideout, 1999).

"Talents cultivating, scientific research, society service, and cultural inheritance" are the four basic functions of universities. As the level of teaching in private universities continue to improve, their importance in talents cultivating has been recognized (Lan, 2013). In 2020, there are 771 private universities in China, accounting for 28.16% of the total number; with 7,913,400 undergraduate and college student accounting for 24.08% of the total number. However, in terms of scientific research, due to the constraints of school orientation, insufficient policy and financial support, low scientific research capability and unreliable scientific research management mechanism, the overall foundation of scientific research in private universities is still weak (Giles, 2012). Therefore, further development of private universities was restricted (Pasternak, 2014). The level of scientific research is the key point for a university to enhance its core competitiveness and upgrade the school, which reflects the quality, the talent cultivation, as well as the faculty for a school (Li, 2021). It is also important to promote the teaching evaluation, to strengthen the enrollment, and upgrade the school level (Hui-Qun, 2011). The role of scientific research is particularly important to build a high-level university. Therefore, how to improve it has become an urgent matter.

The scientific research in private universities involves "Where is the weak point?" "What are the actual concerns about the scientific research?" "What are the gaps between private and public universities in scientific research?" and so on. In order to clearly explore these questions and give more targeted suggestions to private universities to improve their scientific research level, the current situation of scientific research in Chinese private universities was investigated using bibliometric (Baker et al., 2020) method based on Scientific knowledge mapping, or the so called "mapping knowledge domains" technique (Shiffrin & Boerner, 2004).

The research not only provides a summary of the problems and gaps in the scientific research in private universities, but also provide ideas based on bibliometric method for the researchers. The research questions include:

- 1) How to construct the framework of bibliometric method based on mapping knowledge domains?
- 2) How to retrieve the target literature for this study?
- 3) What are the conclusions and suggestions of the scientific research outcome to Chinese private universities?

#### Literature Review

Keyword statistics in literature was used to analyze the research con-

cerns for public and private universities in scientific research. In order to promote scientific research and increase the comprehensive strength of private universities (Deng, 2021; Ouyang, 2019), current situation of college scientific research was refracted to explore situation of scientific research (Xu, 2011; Zhang, 2017). However, there are so many literatures related to scientific research, it is almost impossible to read them one by one and summarize and classify them into different categories. Therefore, the mapping knowledge domains was used in order to quickly obtain relevant research hotspots, trends and themes (Wilkinson & Huberman, 2004). The concept of mapping knowledge domains originated from a workshop organized by the National Academy of Sciences in 2003 (Shiffrin, & Borner, 2004), it is an image that shows the development process and structural relationship of scientific knowledge. The dual nature and characteristics of "diagram" and "spectrum" can be shown in this technique. Many implicit and complex relationships, such as network, structure, interaction, intersection, evolution or derivation among knowledge units or knowledge groups can be shown in this map, so it is a visual knowledge graph and a serialized knowledge genealogy. These complex knowledge relationships are breeding the new generation of knowledge. With the development of information visualization, various tools for mapping scientific knowledge have also emerged. Among them, the knowledge visualization software

CiteSpace (Chen, 2006) has stand out as one of the most popular knowledge mapping tools.

Bibliometric methods are becoming more and more popular in various fields of scientific research with factors such as interdisciplinary approaches and efficient tools to handle big data (Zhou, 2020). An objective and quantitative bibliometric approach avoids the sample selection bias of systematic reviews (Baker et al., 2020). Bibliometrics refers to the science of all knowledge vectors using mathematical and statistical methods for identifying journals, co-authors, co-citation trends, and classic streams of scientific research in a given field of study (Donthu et al., 2021). This approach allows researchers to see connections between evidence, revealing the structure and development of a field. With significant advances in computer technology, which can now handle large amounts of data, bibliometrics has evolved to a new scientific and technical level. The development paths and constitutive relationships of related scientific research fields can be visualized when combining with visualization techniques (Nakagawa et al., 2018).

#### Research Method

Through the process of "literature search, scientific knowledge map, and literature analysis", the status of scientific research was investigated. Firstly, the target literature is retrieved from CNKI by keywords, then imported into

knowledge visualization software CiteSpace to build map, and finally the analysis and judgment are made. The conclusions are drawn by combining the study and analysis results of related papers.

China Academic Periodicals Internet Publishing Database (CNKI) is unified network platform with the most comprehensive academic literature, international literature, dissertations, newspapers, conferences, yearbooks, tools and other kinds of resources in China. Three types of databases, namely, the General Catalogue of Chinese Core Periodicals issued by Peking university Library, the Chinese Social Science Citation Index issued by the China Social Science Research and Evaluation Center of Nanjing university. the platform CNKI were selected for the literature research in this study.

CNKI provides many search tools, yet it is difficult to accurately retrieve the target literature by ordinary search. Professional search function of CNKI using the general formula of professional search expressions: <field code> <matching operator> <retrieval value> was adopted to obtain more accurate search results.

Since the research object of this paper is to find the scientific research status of public and private universities in China, so the search terms are "private universities" or "private college" or "scientific research". While the literature related to public colleges and

universities is generally "colleges and universities", "higher education institutions", or "universities", the keyword "public" does not appear in general, but "colleges and universities", "higher education institutions", or "university" will include private colleges and universities., The target keywords in the fields of "subject", "title", and "keywords" were searched at the same time in order to retrieve literature more completely. The period from January 1, 2010 to January 2, 2010 were selected to ensure the validity of the study.

The search expression for the literature on scientific research in public colleges and universities was: " ( ( SU %='university' OR TI %='university' OR KY %='university' OR SU %='higher education' OR TI %='higher education' OR KY %='higher education' OR SU %='university' OR TI %='university' OR KY %='university') AND ( SU %='research' OR TI %='research' OR KY %='research' ) ) NOT ( SU %='private' OR TI %='private' OR KY %='private' ) ) AND ( YE Between ('2010','2020' ) )". 57,300 target documents were retrieved, including 38,600 academic journal papers, 12,200 dissertations, 856 conference papers, 584 newspaper articles, 226 academic serial papers, and 4782 special journal papers.

To retrieve literature on scientific research in private colleges and universities, the search expression for this study is: " ( ( ( SU %='university' OR TI %='university' OR KY %='university' OR SU %='higher education' OR

TI %='higher education' OR KY %='higher education' OR SU %='university' OR TI %='university' OR KY %='university') AND ( SU %='research' OR TI %='research' OR KY %='research' ) ) AND ( SU %='private' OR TI %='private' OR KY %='private' ) ) AND ( YE Between ('2010','2020') ) "

The search yielded 1467 target documents, among which, 774 were academic journal papers, 487 were dissertations, 13 were conference papers, 2 were newspaper papers, 3 were academic serial papers, and 188 were featured journal papers.

## Results and Discussion

The annual volume of research literature in Chinese public and private universities were analyzed firstly by statistical comparison. Then the keyword hotspots and research trends were analyzed by two kinds of mapping knowledge domains: keyword clustering mapping and keyword timeline mapping.

### (I) Statistical analysis of annual literature volume.

Scientific research outcome of the 57,300 pieces' literature in public universities and the 1,467 pieces literature in private universities are statistically divided into years as shown in Table 1. Figure 1. is the line graphs, with the horizontal coordinate being the year and the vertical coordinate being the number of articles issued in pieces.

According to the statistics of

China's Ministry of Education in 2020, there are 1,967 public universities and 771 private universities in China, and the difference between them in terms of quantity is less than three times. However, from Table 1. and Figure 1, the number of literature on scientific research in public universities is about 40 times more than that in private universities. Therefore, it is obvious that Chinese scholars pay more attention to scientific research in public universities than in private universities.

Because of the excessive difference in the amount of literature on scientific research between public and private universities in China, the annual line graphs for each of them are shown in Figure 1 and Figure 2 to analyze the change of attention with the year. The vertical axis of the annual statistical graph of literature on scientific research in public universities is intercepted above 4000 in order to obviously represent the annual trend.

The trend of literature on scientific research in public and private universities is very similar between 2010 and 2020, as shown in Figure 2 and Figure 3, both of them climb year by year, and have a significant decrease in the year 2020 compared with the previous year.

It is also very doubtful to get such a conclusion from the literature, because the Outline of National Medium and Long-term Education Reform and Development Plan (2010-2020) released by the State Council

Table 1. Annual Statistics Of Literature On Scientific Research  
 In Public And Private Universities In China (Unit: Pieces)

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Public universities	4708	4699	4993	5130	5294	5565	5714	5463	5498	5440	4814
Private universities	74	101	114	141	144	143	145	147	169	165	124

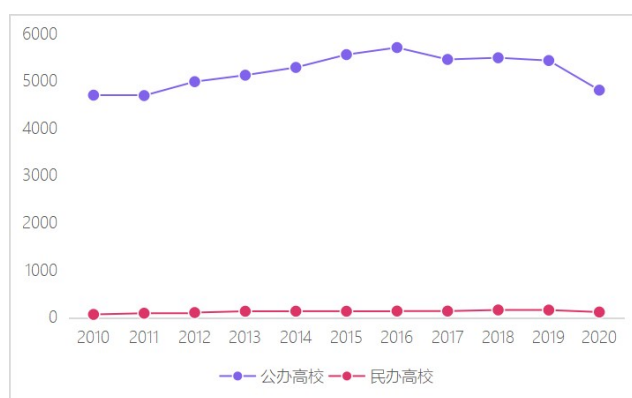


Figure 1. Annual statistics of literature about scientific research in public and private universities in China

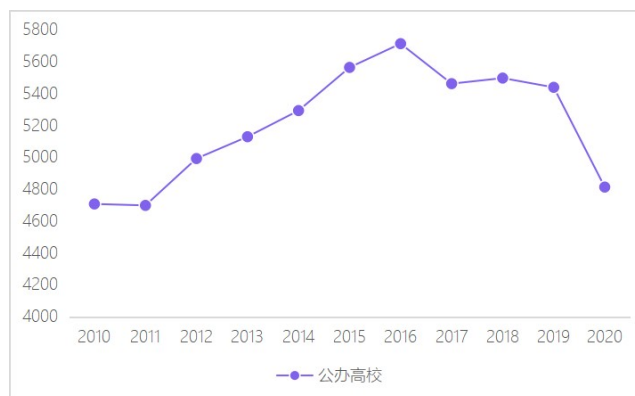


Figure 2. Annual statistics chart of literature on scientific research in public universities in China

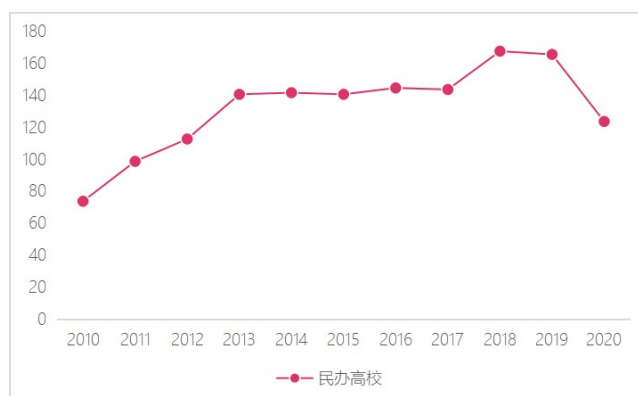


Figure 3. Annual statistics chart of literature on scientific research in private universities in China

of the CPC Central Committee in 2010 clearly points out that "give full play to the important role of universities in the national innovation system, encourage universities to play an important role in knowledge innovation, technology innovation, national defense science and technology innovation and regional innovation" (Council, 2017). The State Council of China and the Ministry of Education of China have also issued several policies and files (Council, 2009; Jiang, 2018) to encourage universities to strengthen scientific research during this period, and these initiatives can well explain the year-on-year increase in the above annual statistical chart, however, the decrease in 2020 cannot be explained.

In response to this query, the central financial expenditure on science and technology through the website of China National Science and Technology Statistics Data Center (<https://www.sts.org.cn/>) were inquired,

and compiled the annual trend as shown in Figure 4. It is found that the central fiscal expenditure for science and technology increased year by year from 205.25 billion yuan in 2010 to 373.85 billion yuan in 2018, however, it fell back to 351.62 billion yuan in 2019, The drop is nearly 6 percentage points, thus it can be understood that the delayed effect of the decrease of the central fiscal expenditure for science and technology in 2019 makes the scientific research fervor about university scientific research in 2020 significantly lower, which is also a warning signal to the scientific research in universities. Fortunately, in 2020, the central financial expenditure for science and technology rises by nearly 7 percentage points from 2019 to a new high of 375.82 billion yuan according to this trend, China's scientific research will develop firmly upward.

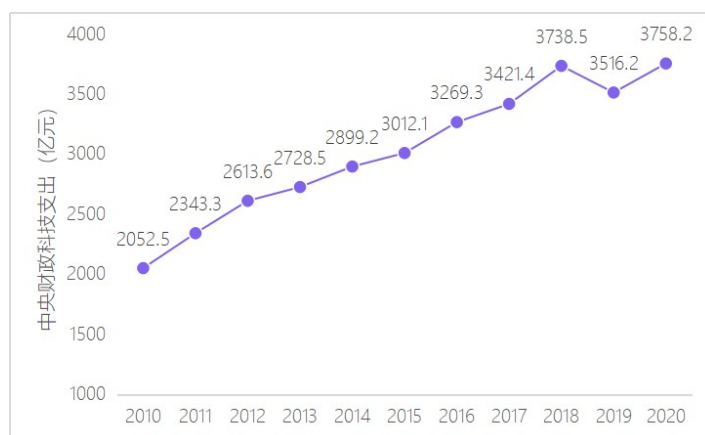


Figure 4. Statistics chart of China's central financial expenditure on science and technology from 2010 to 2020

## (II) Keyword clustering mapping analysis.

Keywords can simply and intuitively show the research content and core points in a field, and the corresponding results can be obtained by analyzing a large amount of literature (Mokhnacheva & Tsvetkova, 2020). Through the keyword clustering mapping of CiteSpace, the vast amount of literature can be better transformed into visualized bibliometric analysis results.

However, the number of literature and nodes analyzed by CiteSpace should not be too many, even thousands of them need a long calculation time, moreover, too much literature will lead to too many nodes and connecting lines of the mapping, and the complicated mapping cannot clearly reflect the aggregation of various keywords. Therefore, 57,300 pieces of literature are arranged in descending order of citation rate in the literature analysis about Chinese public university research, and the top 2000 articles

were analyzed. All 1467 articles were analyzed in the literature analysis of scientific research in Chinese private universities.

After importing the literature into CiteSpace, "keywords" is selected as the network node type to conduct keyword co-occurrence analysis and generate keyword clustering mapping. The basic results of the problem to be analyzed can be intuitively understand, the key direction and important factors of the research problem are able to be clarified, and the existing methods and experiences can be referred to for the subsequent problem solving.

The keyword mapping generated for the literature is shown in Figure 5, where each node represents a keyword, the size of the node circle represents the frequency of the keyword, and the linkage between the nodes represents the co-occurrence relationship between the nodes. Figure 5 only shows the 16 keyword labels with the highest frequency, and the low-frequency key-



word labels are hidden.

Since this mapping is searched by the keywords "university" and "scientific research", it is not surprising that universities are the most frequent keywords, while scientific research is broken down into keyword nodes such as "scientific research", "scientific research funding" and "scientific research management". It is found in the chart that "teachers", as the main body of scientific research, is the second high-frequency keyword, and there are many keywords around it, such as "graduate students" and "talent cultivating". Although "graduate students" and "talent cultivating" are in

the marginal position of the chart, they are also among the top 16 keywords, which fully illustrates that the scientific research in Chinese universities depends on "teachers", "graduate students" and "talent cultivating". At the same time, it is observed that the keywords "collaborative innovation" and "scientific and technological innovation" and "scientific and technological innovation" also appear very frequently, and the position of "collaborative innovation" is almost in the middle of the chart, which indicates the importance of innovation-driven research, and "collaborative innovation" is a very important tool for efficient research, that cannot be ignored.

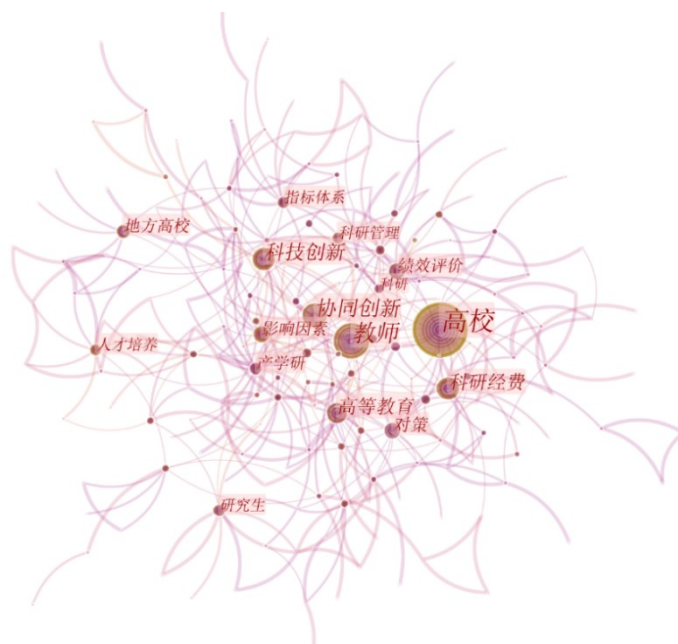


Figure 5. Keywords clustering mapping in the literature on scientific research in Chinese public universities

The keyword clustering mapping of the literature on scientific research in Chinese private universities is shown in the Figure 6, which displays

the 17 keywords labels with high frequency.

The analysis of the mapping

shows that the search keyword "private colleges and universities" has the highest frequency "teachers", "young teachers"; "faculty" and "faculty team" also reflect the people-oriented nature of scientific research in private universities.

However, unlike public universities, "graduate students" is not among the keywords related to personnel in the mapping of private universities, which indicates that postgraduate training in private universities is still very weak. For this reason, this paper has reviewed the relevant materials, and as of September 2019, there are 11 private universities in China with master's degree authorization approved by education departments at all levels, accounting for only 1.4% of the total number, and this proportion is far from the approximately 40% of master's degrees in public universities. From this analysis, strengthening the postgraduate training mechanism is one of the important initiatives for private universities to improve their scientific research level.

In addition, from the keyword clustering mapping of private universities, it is found that the top keywords are more related to incentive and performance, including "incentive", "incentive mechanism", "performance assessment" and "performance management". This indicates that the scientific research in private universities

needs better incentive mechanism and more scientific performance management.

Meanwhile, through comparison, it is found that the keywords related to "innovation" are not found among the top keywords in the keyword clustering mapping of private universities, which shows that the lack of innovation is also an important factor restricting the development of scientific research in private universities in China.

### (III) Keyword timeline mapping analysis.

The keyword timeline mapping is based on the keyword clustering mapping to group the keywords, and the cluster labels are the keywords with the highest frequency in the clusters. The keywords included in each cluster are then expanded onto a timeline according to when they first appeared, from which the development of the research related to a keyword can be analyzed.

The timeline of keywords in the literature on scientific research of public universities shown Figure 7: the rightmost is the cluster volume label, and the left side of the volume label corresponds to the timeline of the keywords appearing in the cluster. Let's take "collaborative innovation" and "scientific research efficiency" as examples for analysis.

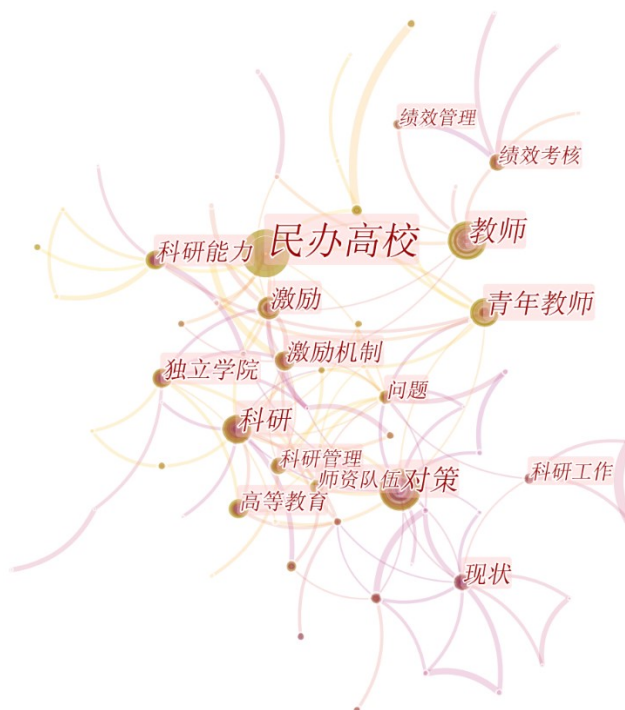


Figure 6. Keyword clustering mapping of scientific research in private universities in China

In the timeline of the "collaborative innovation" cluster, it can be seen that "industry-university-research" and "model" research first appeared in 2010 which is pointed to "collaborative innovation"; then "policy recommendation" and "Mechanism" started to appear in 2011. Then in 2013, the research in "policy recommendations" and "mechanism" started to appear, and in 2013, the research in "management system" and "innovation performance" emerged, till 2017 "decentralization and optimization of services" showed up.

In the timeline of the "scientific research efficiency" cluster, it can be seen that research in "technological innovation" and "disciplinary services" appeared in 2010, it is 2011 that people

started research in "scientific information" and "evaluation", 2013 in "data management", 2017 in "Double First-rate", and 2019 in "collaborative construction" and "double million plan". Keywords timeline mapping in the literature on scientific research in private universities is shown in Figure 8. The three timelines of "scientific research", "scientific research capability" and "scientific research work" were combined related to research to analyze. In 2010, there were studies on "countermeasures" and "development", in 2011, on "scientific research capacity" and "evaluation", and in 2014, on "scientific research management" and "impact", in 2019, on "construction path", "enhancement path" and "Double First-rate" appeared.

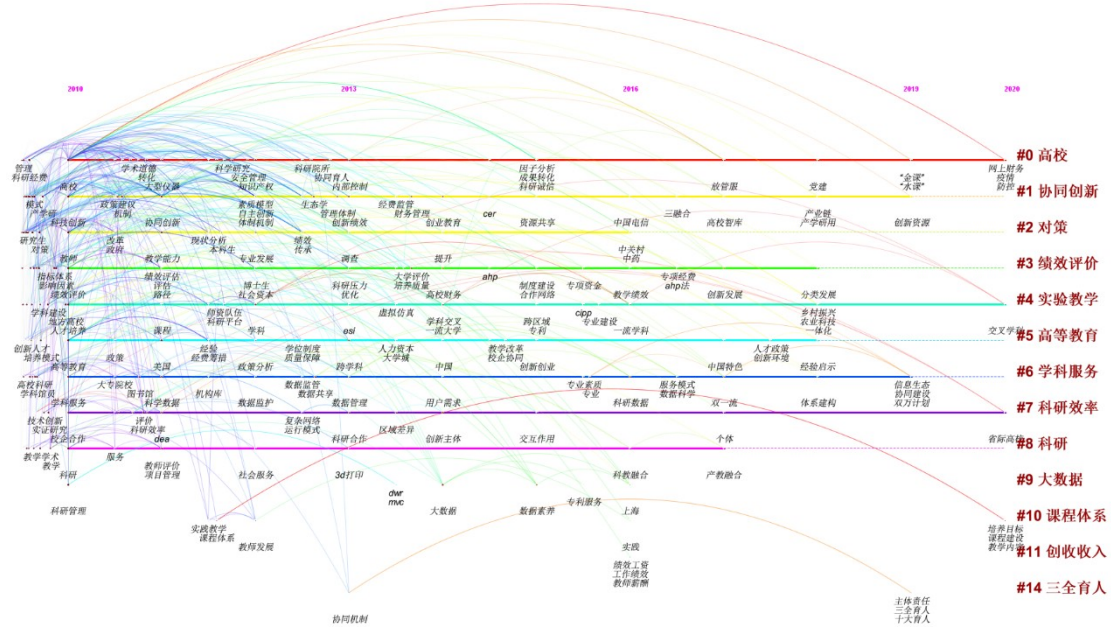


Figure 7. Keywords timeline mapping in the literature on scientific research in Chinese public universities

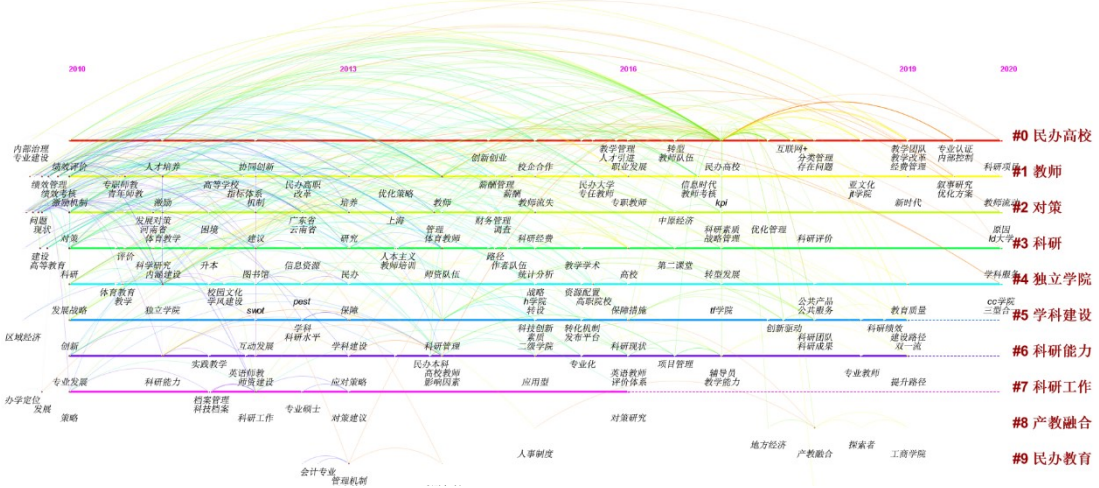


Figure 8. Keywords timeline mapping in the literature on scientific research in private universities in China

### Conclusions and Suggestions

The literature analysis method based on mapping knowledge domains was used in this paper. Current situation of research on scientific research

in Chinese public and private colleges and universities were compared and analyzed and come up with Several points of difference between Chinese private and public universities on scientific research are analyzed through

the statistics of keyword clustering mapping, keyword timeline mapping, and other tools. the conclusions are as follows.

(1) The scientific research in Chinese private universities lack innovation drive.

The scientific research cannot be carried out without innovation. However, the keywords related to "innovation" are missing in the keyword clustering mapping of literature related to scientific research in private universities in China, which is in contrast with public colleges and universities,

(2) The level of talent cultivation in Chinese private universities need to be improved.

In the keyword clustering mapping, there is no "postgraduate" among the keywords related to personnel in Chinese private universities, the analysis reveals that the talent cultivation of Chinese private universities is mainly undergraduate and junior college student, and very few private universities with postgraduate education. Therefore, it is necessary to upgrade the level of talent cultivation in Chinese private universities.

(3) The scientific research in Chinese private universities lack internal driving force.

From the keyword clustering mapping of Chinese private universities, it is found that there are more keywords related to incentive and performance among the top-ranking keywords, which indicates that the scien-

tific research in Chinese private universities focuses a lot on external driving factors as incentive and performance. The external driving force only brings stopgap measures, it is difficult to have high level of scientific research if lacking of internal driving force.

(4) The impact of China's central fiscal expenditure on scientific research cause a lag, but the correlation between the outcome and the input is high.

The annual statistical trend of the number of papers is very similar to the trend of the central financial expenditure, the change of the central financial of China will be delayed about 1 year to react to the attention of the research. Therefore, increasing the investment in scientific research is certainly an important means.

In view of the above problems, the following suggestions to improve the level of scientific research in Chinese private universities were proposed.

(1) Establish a perfect scientific research management system to ensure the smooth development of scientific research

From the actual situation of Chinese private universities, the long-term and short-term plans for scientific research should be developed, the management policies of scientific research projects and scientific research funds should be formulated and improved, so as to standardize, institutionalize and clarify the management of scientific research. It can refer to the system of

public universities to clarify the management in the process of scientific research, so that the scientific research management has a clear rule to follow. The scientific research management department fully takes the principle of "management and administration" to serve scientific research staff and guarantee the orderly scientific research.

(2) Establish a talent cultivation mechanism that combines industry, academia and scientific research to enhance the level of scientific research talents

Scientific research is a humanistic work, and only when there are high-level talents can there be high-level scientific research. private universities need to improve the talent level of their own teachers first, and then actively build the postgraduate training ability to improve the training level of students. Under the current restricted resources, private universities can rely on professional teachers to carry out various kinds of scientific research cooperation with regional enterprises, such as carrying out reform of talent cultivation mode of industry-university-research, establishing scientific research bases and scientific research platforms, etc. to form an influence with good academic reputation, and the cooperation can also better enhance the level of scientific research talents in private colleges and universities themselves, unify the achievements of scientific research and the growth of scientific research talents, and greatly stimulate the internal driv-

ing force of scientific research staff.

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