



## From Industry-University-Institute Cooperation to Collaborative Innovation: an Analysis based on Bibliometrics

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**Abstract:** In this paper, the statistical analysis methods of bibliometrics are used to reveal the evolution of the research skeleton from industry-university-institute cooperation to collaborative innovation. The research progress and direction of collaborative innovation are discussed. Through the analysis of knowledge mapping of keywords in the filed of industry-university-institute cooperation and collaborative innovation, it is found that the relationship between subjects moved from cooperation to coordination, the organization method shifted from the innovation network to innovation ecosystem. The combination of industry-university-institute and collaborative innovation is becoming a special research field that has special meaning and practical background. In the further research, the following several aspects contents are worth in-depth study: the knowledge growth process of industry-university-institute cooperation and collaborative innovation, the dynamic evolution and mechanism of collaborative innovation process, and the effectiveness of the industry-university-institute collaborative innovation based on heterogeneous knowledge value-added.

**Keywords:** Industry-university-institute Cooperation, Industry-university-institute Collaborative innovation, Collaborative innovation, Research skeleton, Bibliometrics

### 1 Introduction

Industry-university-institute cooperation has become strategic measures that help China to accelerate the development of science and technology and the transformation of scientific and technological achievements, to maintain and improve the comprehensive national strength, and enhance the economic competitiveness. Collaborative innovation aims to build an effective collaborative innovation mode, change the way of university innovation, and serve the national development strategies driven by the innovation.

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Collaborative innovation is the organizational mode of innovation in which the integration of large span is carried out by the enterprises, government, knowledge producing organizations (including universities, research institutions), intermediary organizations, and users (Chen and Yang, 2012). Collaborative innovation is different from the cooperation and innovation in general sense, it is not a simple inheritance of industry-university-institute cooperation. Indeed, it is collaboration and integration problem of the functions of the three parties that include industrial development, talent development and scientific research (Hong, 2013; 2014). Therefore, the industry-university-institute collaborative innovation is different from the industry-university-institute cooperation in traditional sense. In the previous work, different understanding and interpretation still exist on the connotative definition and analysis of the industry-university-institute cooperation and collaborative innovation. In order to better carding and concise the connotation of collaborative innovation, we firstly analyze the literature research from the industry-university-institute cooperation and collaborative innovation, applying bibliometric statistical analysis method to reveal the progress from the industry-university-institute cooperation to collaborative innovation, and then discuss the study process and direction of collaborative innovation.

### 2 Treatment and analysis of the research literature

#### 2.1 The source and collection of the research literature

##### 2.1.1 Searching target Journals

Totally, 35 kinds of journals were used in this study. They are respectively: Journal of Management Sciences in China, System Engineering Theory and Practice, Management World, The Journal of Quantitative & Technical Economics, China Soft Science Magazine, Journal of Financial Research, Chinese Journal of Management Science, Journal of Systems Engineering, Accounting Research, Systems Engineering Theory Methodology Applications, Business Review, Journal of Industrial Engineering and Engineering Management, Nankai Business Review, Science Research

Management, Journal of the China Society for Scientific and Technical Information, Journal of Public Management, Journal of Management Science, Forecasting, Operations Research and Management Science, Studies in Science of Science, China Industrial Economics, Issues in Agricultural Economy, Chinese Journal of Management, Industrial Engineering and Management, Systems Engineering, Science of Science and Management of S. & T., R&D Management, China Population Resource and Environment, Journal of Applied Statistics and Management, Chinese Rural Economy, China Higher Education, Journal of Higher Education, Comparative Education Review, Research in Educational Development, China Higher Education Research.

The English target journals we retrieved are primarily recognized internationally as the ten important journals in the field of management and Innovation: Research Policy, Journal of Engineering and Technology Management, Technological Forecasting and Social Change, IEEE Transactions on Engineering Management, R&D Management, Journal of Product Innovation Management, Technovation, Technology Analysis and Strategic Management, Research Technology Management, International Journal of Technology Management.

### 2.1.2 Search Keywords

The Chinese keyword used in the study is Collaborative Innovation (*XIETONG CHUANGXIN*) and Industry-University-Institute Cooperation (*CHANXUE YAN HEZUO*). We took into account that for the scholars, there are a variety of English expression and writing methods of collaborative innovation and industry-university-institute cooperation. In this study, we searched the key words in English are: collaborative innovation, synergy innovation, coordinative innovation cooperative innovation, cooperation innovation, Industry-University-Institute Cooperation, production-education-research cooperation, industry-university-research cooperation, cooperation among IUR.

### 2.2 processing procedure of research literature

First of all, through the database of CNKI, emerald, science direct, and Google academic search, we search related research literature about industry-university-institute cooperation and collaborative innovation according to the keywords set in Section 2.1.2. Secondly, we sort out the summary table of bibliographic information resources. The summary table contains the detailed information of journal, title, keywords, author name, units of author, post time. Finally, we handle the summary table and summary book that record the above information of research literature manually. Through the process of literature collection and processing, we sort out the normative database for our research.

### 2.3 The basic situation of the research literature

Through the above screening and processing, we select 302 papers as the objects of research and analysis, including 279 Chinese papers and 23 English papers,

from 1996-2015. Figure 1 shows the time distribution of the sample literatures. It is worth mentioning that since 2011, the number of Chinese literature has been greatly increased, the higher number reached 50 in 2013.

The sample literature is divided into two categories according to the theme: the literature in which "industry-university-institute cooperation" and "collaborative innovation" can be found in the title or key words. To be clear, "collaborative innovation" is an academic concept with Chinese characteristics, there is no term with the same connotation in the English literature. Therefore, the above second kind of literatures does not include English literatures in the following literature measurement analysis. In addition, the topics or key words of some literatures include both "industry-university-institute cooperation" and "collaborative innovation". Considering that the concept of collaborative innovation is produced on the basis of industry-university-institute cooperation, and the publication time and background of the se literatures, we classify them into the second categories.

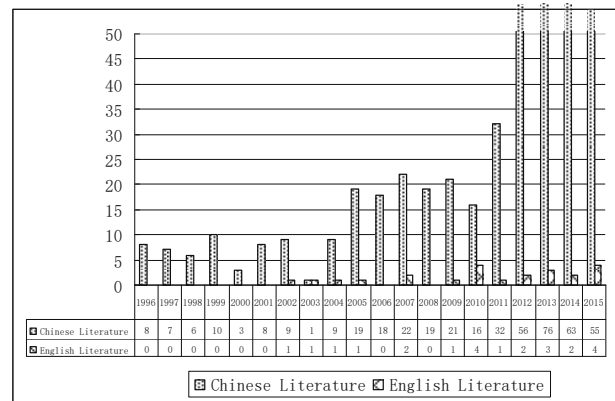


Fig.1 Time distribution of publishing time of sample literatures

The time distribution of the sample literatures after filtering through with different topics is given in Figure 2. The number of various types of literature still shows rapidly increasing trend after distinguishing subjects. There are some obvious trend changes in the quantitative relation. First of all, industry-university-institute cooperation is regarded as an important research topic in the field of science and technology innovation management. Second, after 2012, the literatures on collaborative innovation have increased significantly. Since 2014, the number exceeded that of the literature of industry-university-institute cooperation. The change in the number of literature, to some extent, reflects the changes of research hotspots in recent years, and even indicates that collaborative innovation is likely to replace the original industry-university-institute cooperation, and then become a new research paradigm.

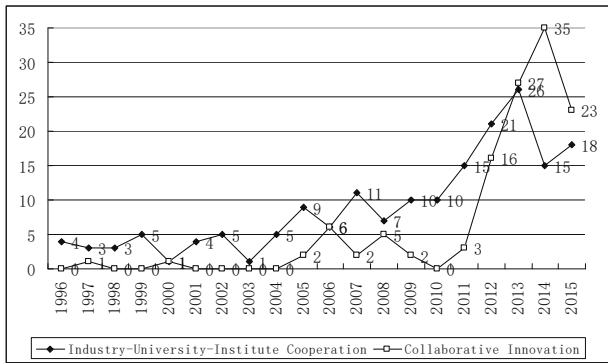


Fig.2 The time distribution of the sample literatures after distinguishing the subjects

### 3 From the industry-university-institute cooperation to collaborative innovation

#### 3.1 Analysis of literature source journals

Among 35 kinds of Chinese journals choose in this paper, there are 16 kinds of journals which published some papers with industry-university-institute as the main theme, and 18 of them published some papers on the theme of collaborative innovation.

First, literature source journals whose theme is industry-university-institute cooperation are more concentrated. Under the theme of industry-university-institute cooperation, the top five journals about the number of papers published a total of 132 papers, accounting for 84.61% of the total number of sample literatures. By way of contrast, the concentration degree of the literature source journals with cooperative innovation as the theme in China is relatively low, the top five journals published 83 papers, with the proportion of 66.94%.

Second, literatures on the subject of industry-university-institute mainly were published in the science and innovation management journals on, especially the four journals: Science of Science and Management of S. & T., Studies in Science of Science, R&D Management and Science Research Management. The literatures with collaborative innovation as the theme, in addition to the above journals, the document numbers of comprehensive journals in education and economic management field with the examples as China Higher Education Research, Research in Education Development and Management World show a marked increase. In essence, this reflects that the research topic of collaborative innovation has a strong interdisciplinary characteristic and has been paid joint attention in the fields of science, education, economic management and other disciplines.

#### 3.2 Analysis of Author and Institution

In Table 2 and 3, we can see that the first ten authors and the institutions. In terms of industry-university-institute cooperative research, the research team of South China University of Technology represented by Xia Fan and Guilong Zhu, and the team of Chinese Academy of Science represented by Guoliang

Yang and Guanghua Chen occupied the leading position in domestic. In the collaborative innovation research filed, the Zhejiang University research team represented by Jin Chen and Gang Zheng, and the team of Shanghai

Tab.1 Top 10 Authors

Industry-university-institute cooperation		Collaborative innovation	
Authors	No.	Authors	No.
1 Xia Fan	10	1 Jin Chen	9
2 Guilong Zhu	9	2 Xuemei Xie	9
3 Weijun Zhong	4	3 Yunfei Shao	3
4 Changhong Yuan	4	4 Gang Zheng	3
5 Guoliang Yang	4	5 Yubing He	2
6 Yuanqiang Tian	4	6 Xiaoxia Lan	2
7 Shue Mei	4	7 Dong Li	2
8 Hedong Liu	4	8 Peifeng Li	2
9 Feng Feng	4	9 Siyu Liu	2
10 Guanghua Chen	4	10 Liang Mei	2

University represented by Xue Mei have become the main research force.

In Tab.1, high yield authors in the two research fields share no one the same at all. This means that, although industry-university-institute and collaborative innovation is two research topics with a clear proper sequence relationship, but few scholars switch between the two research areas. And in Tab.2, the institutions including Chinese Academy of Sciences, Zhejiang University, Tsinghua University, Wuhan University of Technology, University of Science and Technology of China are both high yielding institutions in industry-university-institute cooperation and collaborative innovation. This shows that the research of the institutions has obvious inheritance and continuity.

Tab.2 Top 10 Institutions

Industry-university-institute cooperation		Collaborative innovation	
Institution	No.	Institution	No.
1 South China University of Technology	20	1 Zhejiang University	16
2 Chinese Academy of Sciences	12	2 Shanghai University	7
3 Southeast University	8	3 Shanghai Jiao Tong University	7
4 Harbin Engineering University	7	4 Huazhong University of Science and Technology	5
5 Xi'an Jiaotong University	7	5 Tsing University	5
6 Dalian University of Technology	6	6 Chinese Academy of Sciences	5
7 Tsinghua University	6	7 Peking University	3
8 Wuhan University of Technology	4	8 Xiamen University	3
9 Zhejiang University	4	9 Wuhan University of Technology	3
10 University of Science and Technology of China	4	10 University of Science and Technology of China	3

### 3.3 Mapping Knowledge Analysis

In this paper, we take the key words of 279 Chinese literatures as object. We draw the mapping knowledge based on the co word network, and then refine the hot key words from the research field of industry-university-institute cooperation and collaborative innovation (Fig.3 and 4).

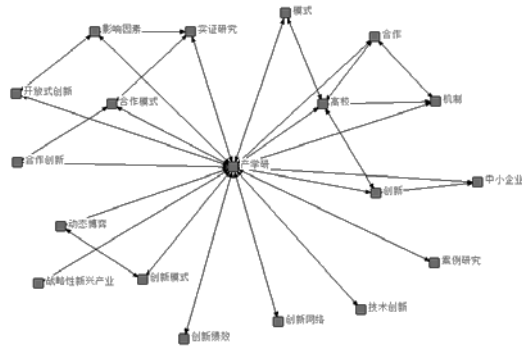


Fig.3 Knowledge mapping of the literatures of “industry-university-institute”

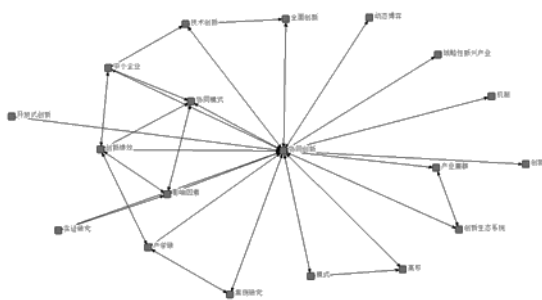


Fig.4 Knowledge mapping of the literatures of “collaborative innovation”

It can be proved that there are 13 common hot keywords in two different sources of literatures, which can be divide into four categories, i.e., the theoretical basis, the research contents, the research methods and the realistic backgrounds. This paper argues that these keywords constitute the two types of research common to follow the research framework (Fig.5). Concrete causes presented below: firstly, the theory of innovation is the common basis of the two kinds of researches. Secondly, the two kinds of researches regard strategic emerging industries as important practical application background. Thirdly, in the research content aspect, the two kinds of researches revolve around the subjects (primarily refer to the universities and small and medium-sized enterprises), mechanisms, modes, influencing factors and innovation performance. Fourthly, in the research methods, common research methods include case study, empirical research and dynamic games.

At the same time, there are five different keywords in the two kinds of literatures. We believe that these differences in the research subjects reflect three important contents of the evolution from

industry-university-institute cooperation to collaborative innovation theory. At first, the relationship between the main bodies turns from cooperation to synergism. Second, the organization way of the subjects converts from the innovation network to the innovation ecosystem. Third, the combination of industry-university-institute and collaborative innovation becomes a research field that is very meaningful and owns certain realistic background.

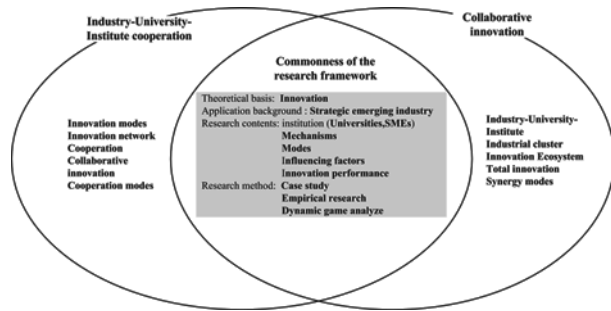


Fig.5 The similarity of research framework and topic differences of the two kinds of literatures

## 4 Research framework and theoretical evolution

### 4.1 Commonness of the research framework

For industry-university-institute cooperation and collaborative innovation, both of them are based on the innovation theory, and the common important practical application background is strategic emerging industry (Such as, Shen, 2012, Wu and Gu, 2014, etc.).

Industry-university-institute cooperation relates to the cooperation between industrial capital and intellectual capital (Xiao and Shen, 1999). Through the industry-university-institute cooperation, it is important way to win the competitive advantage by transferring the external knowledge to internal knowledge of enterprises in order to create values. Generally, scholars believe that the external knowledge learning and knowledge transferring is the main mechanism by industry-university-institute cooperation to gain profits. So in the discussion of the industry-university-institute cooperation mechanism, the effect factors of knowledge learning and knowledge transfer, the conflicts and coordination of intellectual property and the distribution of interests all become the main research questions. In collaboration with the research of industry-university-institute cooperation, the researches in the field of collaborative innovation suggest that collaborative innovation involves the overall integration of knowledge, resources, behaviors and performances; the integration mainly includes knowledge, resources, actions and performances. Therefore, the main mechanism of collaborative innovation is knowledge collaboration and its impact to the knowledge increment.

### 4.2 Theoretical Evolution

#### 4.2.1 From cooperative to collaborative

Based on the bibliometric analysis of the above

literatures, we find that related research of industry-university-institute cooperation focuses more on the interaction mechanism based on bilateral cooperation, such as conflicts, coordination and the profit allocation in cooperative innovation. However, synergetic theory is the basis of the related researches of collaborative innovation that focus more on coordination mechanism based on in-depth cooperation and integration between multiple innovation subjects. In fact, the idea of collaborative innovation comes from the related researches in industry-university-institute cooperation innovation and open innovation in the later stage. The evolution of the relationships between the main bodies is characterized by collaboration that is conversed gradually by cooperation.

#### **4.2.2 From the innovation network to the innovation ecosystem**

In the process of industry-university-institute cooperation and collaborative innovation, there is cooperative and interactive relationship among multi agents that showed more obvious characteristics of the network. So, in the study, many scholars think that their main organization is innovation network.

Scholars pursue research of industry-university-institute cooperation network by using various views, such as associal network (Ding et al., 2012), and complex network (Zhang et al., 2013, 2015; Gao and Chen, 2015). In the research of collaborative innovation, through the summary of the scholars' wisdom, we can conclude that collaborative innovation is both a new paradigm of technological innovation and a kind of innovation organization pattern with the added value of knowledge as the core, the innovation organization mode among multiple subjects, the nonlinear superimposed effects of collaborative interactive innovation model based on network. So the research of collaborative innovation network increases more rapidly in collaborative innovation research, it is an important research direction on the perspective of innovation network in the research field.

When the network research of main organization modes is under way, some scholars try to reference and use other theoretical framework to analyze and explain the industry-university-institute cooperation and collaborative innovation.

#### **4.2.3 Industry-University-Institute Collaborative innovation as a new research field**

Along with the theoretical evolution from the industry-university-institute cooperation to collaborative innovation, a new keyword has emerged in the research filed in recent years. By analyzing the latest researches, we find that industry-university-institute collaborative innovation is different from industry-university-institute cooperation in traditional sense. It also has minor difference with collaborative innovation. It can be found that the difference is mainly manifested in the following aspects based on the former research: (1) The researches

of industry-university-institute collaborative innovation put more emphasis on the difference of the main bod. (2) The researches of industry-university-institute collaborative innovation put more emphasis on the heterogeneity of knowledge. (3) The researches of industry-university-institute collaborative innovation place more emphasis on conflict coordination, interface management and the maximum of profits based on the overall. Thus, we can conclude that industry-university-institute collaborative innovation has become a new study area that has a specific meaning and practical background.

#### **4.3 Future research**

From industry-university-institute cooperation to collaborative innovation, and then to industry-university-institute collaborative innovation, a progressive and gradual deepening of theory evolution has been developed. The research trends include: (1) a more in-depth analysis of the process of value added of the knowledge of industry-university-institute cooperation and collaborative innovation that is the core of value creation of industry-university-institute cooperation and collaborative innovation. A more clear description of the process is helpful to in-depth and complete understanding for industry-university-institute cooperation and collaborative innovation in theory and to improve the effects of industry-university-institute cooperation and collaborative innovation in practice; (2) To further deepen the dynamic research perspective, analyzing the evolution models and dynamic mechanisms of collaborative innovation is a necessary research topic that is determined by the characteristics of collaborative innovation; And (3) Strengthening the understanding of the effectiveness of industry-university-institute collaborative innovation based on value added of heterogeneous knowledge is the basis of improving the process of industry-university-institute collaborative innovation and improving the performance of industry-university-institute collaborative innovation. From the existing literatures, the current research of the above research propositions is still not perfect.

#### **5 Conclusion**

Based on the collection and collation the literatures of industry-university-institute cooperation and collaborative innovation in domestic and foreign, we grasp the current research situations by keywords or keywords analysis. According to the analysis of knowledge mapping, we obtain that the theoretical research thoughts from industry-university-institute cooperation to collaborative innovation. Through the combination of qualitative methods and quantitative methods, we put forward the progress and direction of current research in industry-university-institute cooperation to collaborative innovation. Our research favors further grasping the research thoughts of industry-university-institute cooperation and collaborative innovation, and is beneficial to understand the further research direction of collaborative innovation, and provide scientific basis for the design of related

researches in the future.

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