Co-authorship Network Analysis of NSFC-Supported '985' and '211' Universities: Postprint

Authors: Meng Xiangtian, Bao Yilin, Zhao Yinghui

Date: 2023-10-08T00:00:00+00:00

Abstract

[Purpose/Significance] Investigating the current status of scientific research collaboration among "985" and "211" universities can facilitate the effective implementation of the "2011 Plan". [Method/Process] Using CNKI (China National Knowledge Infrastructure) as the data source, this study retrieved co-authorship data of papers supported by the National Natural Science Foundation of China from 2004 to 2014, and employed social network analysis methods to examine the co-authorship patterns among "985" and "211" universities. [Results/Conclusion] Among the 116 universities, Tsinghua University exhibits the highest degree centrality, indicating its central position; geographical location and spatial distance significantly influence the intensity of research collaboration ties between universities; universities with interdisciplinary or similar disciplines exhibit stronger connections; "985" universities publish more papers, and collaboration among them is also relatively strong.

Full Text

Preamble

ChinaXiv Cooperative Journal [Academic Exploration]
Analysis of Co-authorship Networks among "985" and "211" Universities Supported by the National Natural Science Foundation of China
Meng Xiangtian, Bao Yilin, Zhao Yinghui
College of Resources and Environment, Northeast Agricultural University, Harbin 150030

Author Information: Meng Xiangtian (ORCID: 0000-0001-7089-0020), undergraduate student, E-mail: 741799556@qq.com; Bao Yilin (ORCID: 0000-0003-0379-4910), undergraduate student; Zhao Yinghui (ORCID: 0000-0002-2459-8321), Department Chair, Associate Professor, Ph.D.

Received Date: October 9, 2016
Publication Date: December 29, 2016
Responsible Editor: Wang Shanjun

Abstract

[Purpose/Significance] Investigating the current state of scientific research collaboration among "985" and "211" universities can facilitate the better implementation of the "2011 Plan." [Method/Process] Using CNKI (China National Knowledge Infrastructure) as the data source, we examined co-authorship data supported by the National Natural Science Foundation from 2004 to 2014, applying social network analysis methods to study paper co-authorship patterns among "985" and "211" universities. [Result/Conclusion] Among 116 universities, Tsinghua University exhibits the highest degree centrality, indicating its position as the most important node. Geographical location and spatial distance significantly influence the intensity of collaborative ties between universities. Institutions with overlapping or similar disciplines tend to have closer connections. "985" universities not only publish more papers but also maintain tighter collaborative networks among themselves.

Keywords: paper co-authorship; scientific research cooperation; social network analysis
Classification Number: G250
Citation Format: Meng Xiangtian, Bao Yilin, Zhao Yinghui. Analysis of co-authorship networks among "985" and "211" universities supported by the National Natural Science Foundation of China [J/OL]. Knowledge Management Forum, 2016, 1(6): 449-456 [citation date]. http://www.kmf.ac.cn/p/1/82/.

Introduction

On May 7, 2012, the Ministry of Education and the Ministry of Finance officially launched the Higher Education Institution Innovation Capability Enhancement Plan (also known as the "2011 Plan"), which aims to comprehensively improve the quality of higher education by breaking down institutional barriers within and between universities and unleashing the vitality of innovative elements such as talent and resources. As the third national-level initiative in China's higher education system following the "985 Project" and "211 Project," this plan represents a major strategic measure reflecting national will in the new context of universities' connotative development. Inter-university research collaboration and cooperation have become crucial factors in responding to the "2011 Plan." Therefore, understanding the state of domestic university collaborations and enhancing their quality is essential for implementing the "2011 Plan."

Literature Review

To explore co-authorship networks among universities, numerous scholars have conducted research. Sun Ning et al. studied the most influential papers in

co-authorship networks [1]. Zhong Xu et al. analyzed co-authorship rate indicators in Chinese social science journals and predicted their development trends [2]. American scholars B. F. Jones, S. Wuchty, and B. Uzzi revealed the importance of paper co-authorship for scientific development [3]. Chen Wei et al. analyzed the complexity of research collaboration networks among "985" universities and explored underlying patterns [4]. Yuan Run et al. uncovered characteristics, current status, and existing problems of author co-authorship in China's library and information science field [5]. Concurrently, research on contributors emerged; Zhao Jingjing et al. analyzed paper collaborations among Florence Nightingale Medal recipients, providing reference points for nursing development in China [6]. Lin Runhui et al. explored the relationship between collaboration network attributes and performance among Chinese management scholars from multiple perspectives [7]. Research has transitioned from focusing on papers themselves to analyzing research methodologies. S. Sun and S. M. Manson's study demonstrated that an increasing number of scientists are adopting social network analysis for quantitative data analysis [8]. Ji Yilong applied social network analysis to examine connectivity, average distance, and efficiency in co-authorship networks of 60 highly productive universities [9]. Fan Xiangwei and Xiao Xiantao studied and analyzed algorithms for allocating contributions among co-authors [10]. Yang Gang revealed the complex weighted nature of research team collaboration networks through quantitative analysis of network attributes [11]. Chen Shaolong [12], Li Liang [13], Zhang Xiumei [14], and Zhang Dawei [15] applied social network analysis to analyze co-authored literature from different perspectives.

2.1 Data Sources

Co-authorship data were obtained from the China Journal Full-text Database of CNKI (China National Knowledge Infrastructure). The search scope covered the number of collaborative papers between "985" and "211" universities from 2004 to 2014. Search method: Journal period from 2004 to 2014, funding source = National Natural Science Foundation, author affiliation = "211" or "985" institutions. The search was conducted by entering one "211" or "985" institution in the author affiliation field to retrieve literature, then entering another "211" or "985" institution to search within those results. Based on the retrieved co-authorship data, we used Excel software to construct a 116$\times$116 co-authorship matrix between universities, defined as follows:

where m and n represent different universities, and Sij represents the number of co-authored papers between universities i and j. The data were then imported into UCINET for network analysis and calculation.

2.2 Data Processing Methods

Network analysis is currently the most widely used method, and UCINET software is an important tool in network analysis. The main variables used by this

software to describe network structural properties include clustering coefficient, network density, centrality, and tie strength.

2.2.1 Centrality Analysis

Centrality is a key focus in social network analysis, similar to the concept of "power" in social networks. Centrality is divided into three types: degree centrality, betweenness centrality, and closeness centrality. Degree centrality is often used to measure whether an individual plays the most important role in a group; if a person occupies a central position, they possess greater power and thus have higher degree centrality. Betweenness centrality can measure an individual's ability to control resources and determine whether they occupy an important position with the capacity to mediate interactions between other pairs of individuals.

2.2.2 Cluster Analysis

Clustering is an important factor in social network analysis. It is the process of classifying data into different classes or clusters, where objects within the same cluster have high similarity while objects in different clusters have high dissimilarity. This paper divides all universities into several clusters to analyze the factors influencing inter-university paper collaboration from different clusters.

3.1 Centrality Analysis

3.1.1 High Degree Centrality of "985" Universities

Table 1 is arranged in descending order by average degree centrality. The table shows that during 2004-2013, Tsinghua University and Peking University consistently held absolute core positions, alternating as the absolute center. Based on the 11-year average of degree centrality values, Tsinghua University's degree centrality is higher than Peking University's, but the gap is small at approximately 3%. Universities ranked 3rd to 10th are Shanghai Jiao Tong University, Zhejiang University, Tongji University, Nanjing University, University of Electronic Science and Technology of China, Jilin University, Wuhan University, and Beijing Normal University, which also possess relatively high core status. Among universities ranked 11th to 30th, the vast majority are "985" universities, demonstrating that "985" universities play a leading role overall.

As can be seen from Table 1, Tsinghua University and Peking University have consistently maintained leading average betweenness centrality, indicating their indispensable roles in the overall network, which is inseparable from their geographical locations and research strengths. Starting from the third position (Shanghai Jiao Tong University), average betweenness centrality shows a clear downward trend, with Shanghai Jiao Tong University's value about 4% lower than Tsinghua University's in second place. Among universities ranked 5th to 30th, most have betweenness centrality greater than 1%, indicating that

these institutions also control considerable research information and resources and possess strong capacity to operate within the network. Some universities have low betweenness centrality because they are not research-oriented institutions. Communication University of China, Beijing Sport University, Beijing Foreign Studies University, China University of Political Science and Law, and Shanghai International Studies University have enhanced external paper collaboration in the subsequent ten years, with improved betweenness centrality. The betweenness centrality of remaining universities remains relatively stable, generally ranging from 0.3% to 1.0%.

3.1.2 Centrality Analysis of Western Region Universities

Among western universities, most "985" universities have higher degree centrality than "211" universities. However, Northwest A&F University's degree centrality is lower than that of Northwest University, Southwest Jiaotong University, Xidian University, and Shaanxi Normal University. The reason may be that although Northwest A&F University is a "985" university, its remote location and focus on agricultural sciences with limited involvement in other fields result in lower degree centrality. In contrast, although Northwest University, Southwest Jiaotong University, Xidian University, and Shaanxi Normal University are "211" universities, their individual disciplines are stronger than those of some "985" universities, enabling these four institutions to play a leading and exemplary role in western China. Tibet University ranks last in the western region due to the impact of its special geographical location, underdeveloped regional economy, declining educational resources, and brain drain, which reduce its connections with other universities and consequently lower its degree centrality.

3.1.3 Low Degree Centrality of Specialized Universities

The six universities with the lowest degree centrality are Communication University of China, Beijing Sport University, Beijing Foreign Studies University, China University of Political Science and Law, Shanghai International Studies University, and Central Conservatory of Music. These six institutions are all "211" universities but not comprehensive universities; instead, they focus on specific areas such as cultural communication, arts and sports, languages, and law. They publish few papers and even fewer co-authored papers with other universities, resulting in very low degree centrality between 0.3% and 4.9%. These six universities experienced periods with degree centrality of zero during these 11 years, with Central Conservatory of Music being the most special case, showing zero degree centrality in six years: 2004, 2005, 2006, 2008, 2010, 2013, and 2014. The remaining universities show degree centrality fluctuating within a small range. The six universities with the lowest betweenness centrality are the same: Communication University of China, Beijing Sport University, Beijing Foreign Studies University, China University of Political Science and Law, Shanghai International Studies University, and Central Conservatory of Music.

In 2004, all six had betweenness centrality of zero, indicating they played no intermediary role in the co-authorship network. In the subsequent ten years, only Central Conservatory of Music maintained zero betweenness centrality, possibly because it is not a research-oriented institution.

3.2 Characteristics of Universities with Weak Network Connections

When node degree is greater than 1 or 2, connections exist between universities, but the characteristics of weakly connected institutions are not obvious. Figures 1 [Figure 1: see original paper] through 3 [Figure 3: see original paper] show network structure diagrams with node degrees greater than 3, meaning a connection between two universities is only displayed if they have co-authored at least 4 papers. Universities with node degrees less than 3 that appear frequently are specialized institutions with fewer disciplines, such as Beijing Sport University, Central University of Finance and Economics, Communication University of China, Central Conservatory of Music, Beijing Foreign Studies University, Shanghai International Studies University, Northwest University of Finance and Economics, and the Fourth Military Medical University. These are professional universities with relatively narrow research directions closely corresponding to specific professions.

3.2.2 Limited Network Connections for Remote Universities

Some universities in remote areas, such as Tibet University, Yunnan University, Qinghai University, Inner Mongolia University, and Xinjiang University, have weaker research capabilities compared to other “211” and “985” universities. With underdeveloped local economies providing less support than central and eastern regions, these universities have relatively weaker soft power. Consequently, they receive few National Natural Science Foundation projects, publish fewer papers under this support, and have even fewer co-authored papers. Naturally, these universities show weak connections with others in the co-authorship network.

3.2.3 Unstable Network Connections for Less Comprehensive Universities

Universities such as Minzu University of China have gradually strengthened connections with other institutions, with increasing numbers of co-authored papers. However, China Medical University, Beijing University of Chinese Medicine, Beijing University of Posts and Telecommunications, and Soochow University show instability in their connections with other schools. For example, China Medical University had weak connections with other universities in 2004, 2011, and 2012. Therefore, these universities need to further strengthen their capacity for scientific research collaboration.

3.2.4 Overall Strengthening of Inter-university Co-authorship Networks

Over these 11 years, the number of weakly collaborating schools decreased as network density increased. The number of universities with fewer than 4 co-authored papers dropped from 18 to 8, indicating more frequent connections between universities. This not only promotes development in disciplinary fields but also lays a good foundation for other related collaborations. Table 1 shows that the number of tightly connected universities remains relatively stable while still improving under constant node conditions. In other words, when nodes relatively decrease, there is a more significant increase in paper collaboration quantity, which may be related to the implementation of the "2011 Plan."

3.3 Network Cluster Analysis

To understand which factors promote connections between universities, we further increased the node degree threshold to 20. At this point, the number of nodes and connections in the network decreased significantly (Figures 4 [Figure 4: see original paper] through 6 [Figure 6: see original paper]). The factors influencing the intensity of inter-university connections mainly fall into two categories: First, geographical differences. Taking 2014 as an example, Harbin Institute of Technology, Harbin Engineering University, Dalian University of Technology, Dalian Maritime University, and Northeast Forestry University formed a northeastern university system; Tsinghua University, Peking University, Beijing Normal University, and University of Science and Technology Beijing formed a north China system; Jinan University, Sun Yat-sen University, South China Normal University, and South China University of Technology formed a south China system; East China University of Science and Technology, Shanghai Jiao Tong University, Tongji University, and Fudan University formed an east China system. Each region formed characteristics of tight inter-university connections within its area, demonstrating that regional location is an essential factor in whether universities have close connections. Second, the influence of interdisciplinary overlap. Some universities overcome geographical disadvantages to form close connections with distant institutions, while others form tight connections purely due to similar disciplines. For example, Beijing University of Technology and Harbin Institute of Technology are both engineering-focused universities; University of Electronic Science and Technology of China, Xidian University, and Zhejiang University have significant advantages in communications and electronics; Tianjin University is a science and engineering university. These institutions form different university systems based on their different types.

4 Conclusions

(1) "985" universities occupy central positions in scientific research collaboration. Universities with high centrality are comprehensive "985" institutions with strong overall strength. Tsinghua University has the highest

degree centrality at 70.277%, indicating its close connections with other universities, very strong research capabilities, multiple and strong disciplinary areas, significant influence in university research fields, and core position in the co-authorship network. Peking University has the highest betweenness centrality at 7.901%, showing its ability to build collaborative networks with other institutions, play an intermediary bridging role, and exert significant influence in co-authorship.

(2) Collaboration between universities shows clear tendencies. Spatial distance has a noticeable impact on co-authorship, with significantly more co-authored papers between universities in the same city or nearby locations. Disciplinary characteristics are also important factors driving scientific research collaboration.

(3) Only a few universities exhibit characteristics of strong and stable collaboration in the co-authorship network. Most universities have insufficient depth and intensity of scientific research collaboration, with low network density.

(4) Inter-university co-authorship network connections show an overall trend of strengthening.

5 Recommendations

Based on the above conclusions regarding characteristics of scientific research collaboration among "985" and "211" universities, several reference points emerge for national education management and scientific research. First, "985" universities and regionally central universities with high centrality should play leading roles in improving regional research levels, focusing on quality while achieving breakthroughs in institutional mechanisms. Second, universities in different regions should strengthen connections, especially those in remote and underdeveloped areas, which is crucial for driving the research capabilities and academic standards of entire regions. Finally, universities with specialized disciplines and those whose interdisciplinary collaboration has not yet reached high levels should actively respond to the national "2011 Plan," seize opportunities, move from closed to open systems, break regional and disciplinary constraints, promote scientific and technological reform and innovation system construction, and strengthen inter-university exchanges.

To actively respond to the "2011 Plan," universities with poor collaboration levels should: first, change their current state of being "scattered, closed, and inefficient" to fully unleash the vitality of talent and educational resources; second, actively respond to research policies and advocate new collaborative concepts to overcome contradictions and obstacles. The nation should also adjust relevant financial systems, pay attention to local development, strengthen special construction projects, and enable economically disadvantaged regions to have the capacity to exchange with other regions.

It should be noted that this study has certain limitations. The analysis does not examine the relationships among paper co-authors (such as whether they are teacher-student relationships) or analyze job mobility. Regarding paper quantity, the study does not explore the number of collaborating universities per paper, only searching from the perspective of two institutions, which reduces the degree of association between universities. Additionally, this research only conducts centrality analysis and overall network analysis of collaborations. Future studies should conduct in-depth research on inter-university co-authorship from multiple perspectives.

References

[1] Sun Ning, Zhu Jiaming, Cheng Hao, et al. Research on paper co-authorship relationships based on social network analysis [J]. Journal of Suzhou University, 2014, 29(9): 46-49.
[2] Zhong Xu, Huang Hui, Xue Jian. Research on the current status and development trends of co-authorship rate indicators in Chinese social science journals [J]. Journal of the China Society for Scientific and Technical Information, 2000, 19(3): 280-
JONES B F, WUCHTY S, UZZI B. Multi-university research teams: shifting impact, geography, and stratification in science [J]. Science, 2008, 322(5909):
[4] Chen Wei, Zhou Wen, Lang Yifu, et al. Analysis of scientific research cooperation networks based on co-authorship and citation networks [J]. Information Studies: Theory & Application, 2014, 37(10):
[5] Yuan Run, Wang Hui. Research on co-authorship phenomena in library science papers based on social network analysis [J]. Library and Information Studies, 2010(3): 37-40.
[6] Zhao Jingjing, Duan Zhiguang. Social network analysis of paper collaborations among Florence Nightingale Medal recipients in China [J]. Nursing Research, 2015(12): 1460-1462.
[7] Lin Runhui, Fan Jianhong. Research on the attributes of Chinese management scholars' paper collaboration networks and their impact on collaboration performance [J]. R&D Management, 2012, 24(4): 81-92
[8] SUN S, MANSON S M. Social network analysis of the academic GIScience community[J]. Professional geographer, 2011, 63(1): 18-33.
[9] Ji Yilong. Research on the current status of paper co-authorship in China's educational technology discipline [J]. China Medical Education Technology, 2014, 28(4): 363-366.
[10] Fan Xiangwei, Xiao Xiantao. Research progress and comparative analysis of algorithms for allocating contributions among paper co-authors [J]. Library and Information Service, 2015, 59(10): 116-123.
[11] Yang Gang. Research on the complex weighted properties of research team paper collaboration networks [J]. Journal of Intelligence, 2009(7): 7-11.
[12] Chen Shaolong. Application of social network analysis in co-authorship networks at the School of Management, Shanghai University [J]. Modern Information, 2012, 32(4): 165-168.

[13] Li Liang, Zhu Qinghua. Empirical research on the application of social network analysis in co-authorship analysis [J]. Information Science, 2008, 26(4): 549-555.
[14] Zhang Xiumei, Wu Wei. Visualization of scientific research cooperation networks and its application in literature retrieval services [J]. Journal of the China Society for Scientific and Technical Information, 2006, 25(1): 9-15.
[15] Zhang Dawei, Xue Huifeng, Kou Xiaodong. Network analysis of scientific collaboration in the field of complex networks [J]. Journal of Intelligence, 2008(8): 143-148.

Author Contributions

Meng Xiangtian: Data collection and organization, writing the initial draft;
Bao Yilin: Chart production, computational analysis, revision and improvement;
Zhao Yinghui: Providing ideas, revision suggestions, and overall guidance.

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