Analysis of Productive Authors' Co-authoring Relationship in Economics*

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Abstract: The co-authoring relationship is the most obvious and direct among all the forms of cooperation between scientific researchers. Co-authored papers, as an important output of academic activities, can reflect the state of cooperation among scholars in our country. Based on the academic literature in economics in the SSCI database from 2004 to 2019, this paper uses Python and Pajek to analyze the characteristics of the co-authoring network of high-yield authors, and finds closely connected groups in the co-authoring network.

1. Introduction

With the rapid development of social economy and technology, the number of scholars engaged in scientific research has been increasing, and a stable group of researchers specializing in science and technology has been formed in all disciplines. At the same time, the interdisciplinarity and comprehensiveness of disciplines are becoming more and more obvious. It has become increasingly difficult for scientific researchers to complete scientific research independently, and team cooperation to declare and complete scientific research projects is also becoming more popular. Corresponding to this demand, the development of various communication technologies, especially network technologies, has brought great convenience to the communication among scientific researchers, and cooperative innovation among scientific researchers has become one of the mainstream academic innovation modes. Scientific research cooperation is a very mainstream and common form of academic activities nowadays. As an important output of academic activities, co-authored papers can reflect the current state of academic cooperation from a certain aspect, and provide a glimpse of basic research and applied research in a country and region. The research on the publication of co-authored papers in various academic fields will help to better understand the level of academic development and the competitiveness of scientific research.

In fact, in recent years, a large number of domestic scholars in various fields have used different analysis methods to conduct co-authored analysis of academic literature of different dimensions and levels and published numerous articles. For example, Tan Chunhui et al. [1] used 17 core journals of ISLS (Information Science Library Science) in the Web of Science database in the 10 years from 2007 to 2017 as data sources, and evaluated the influence of scientific research subjects through TOPSIS analysis method based on entropy weight. By combining network analysis and time series analysis, Sun Xionglan et al. [2] tracked and analyzed the branch structure, the intensity of co-authorship and the intensity of co-authorship in the time series co-authorship network, and explored the evolution mode and emergence rule of the co-authorship network. Through cluster analysis, Xu Lingxin [3] found that the forms of co-authoring networks of engineering management disciplines in 30 universities could be classified, and the specific classification types are: weak intermediary intensive network, medium intermediary, weakly connected network, strong intermediary, centralized network and multi-intermediary, average network. Based on the analysis of the co-authoring network of the paper, combining it with the scientific research background of academic staff, it can be found that there are three types of "mentoring relationship", "attribute under leadership" and "scientific research clustering" in the field of engineering management. Liu Yang [4] collected data from CNKI in the past 15 years from 2002 to 2016, constructed the co-authorship matrix, and analyzed the co-authorship in the field of library and information from three perspectives, point degree centrality, intermediate

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centrality and close centrality. Zhang Hefan et al. [5] selected the Department of Information Management of Peking University as the research object, used Ucinet6 to analyze the centrality and visualization of the co-authoring network of scholars in the library and information agency, and used social network analysis method to study the co-authored phenomenon in the library and information agency in China. Research on related topics can be described as fruitful.

As is known to all, there are many forms of contact between scientific researchers, such as co-publishing articles, engaging in common scientific research tasks in the same fund project group, guiding papers as supervisors, participating in well-known academic conferences at home and abroad for exchanges and cooperation, academic citation, and relationship between classmates or colleagues. Among them, the co-authoring relationship is currently the most obvious of all forms of cooperation, and the data is relatively easy to obtain, and the co-authoring relationship between authors is used to express the most direct relationship between each other. Economics, as a highly intersecting discipline, has inherent and natural connections with other disciplines since Smith's creation. It requires researchers to possess various professional knowledge in a specific field such as mathematical statistics, political science, ethics, law, and psychology, requires close cooperation to achieve complementary advantages. The most common form of this phenomenon in output is the co-authorship of academic papers, which leads to a growing network of co-authors. Based on the literature data of SSCI journals in the field of economics, this paper analyzes the co-author-network of high-yielding authors.

2. Research Method

2.1 Data acquisition and filtering

In this paper, English papers and reviews in the economics in the SSCI database from 2004 to 2019 are collected using the packaged acquisition as shown in Fig. 1, and the author's full name in AF field is analyzed based on the co-author-based scholar association social network.

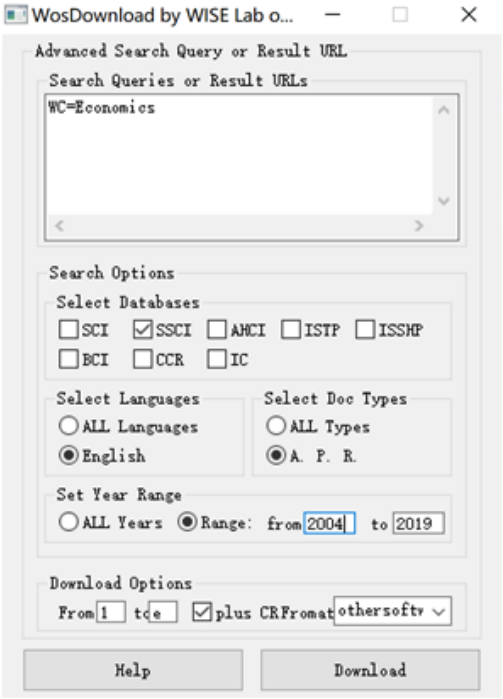

Fig 1. Data acquisition interface.

Since the research object of this paper is co-author network, python code is first written according to the collected data source table to delete the record of a single author, that is, each paper is required to contain at least two authors. Considering that the article with the largest number of co-authors in the data source table contains 74 authors, the number of leads generated by any one of the authors as a node in social network analysis will reach 73, which will have a great impact on analysis and

visualization. In addition, considering that if the number of co-authors is too small, it will easily lead to the lack of author data, so this article selects the first 10 co-authors of each article for co-authoring network analysis. In the data source table, the number of papers with more than 10 coauthors was 357, which only accounted for 0.14% of the total number of papers 248,067, and the theoretical analysis error was relatively small.

2.2 Data processing and analysis

By counting the frequency of authors' co-authored papers through Python, the number of co-authored papers published by each author can be obtained, including papers published as non-first authors. The large number of co-authored papers published indicates that the author plays an important role in the co-authored network to some extent. Fig. 2 lists some authors who have co-authored papers more than 40 times. Furthermore, the author's co-occurrence matrix and social network analysis methods can be used to visually identify the co-authoring network of high-yield authors, so as to intuitively reflect the co-authoring situation between authors. Due to the large number of authors, in order to improve the visualization effect, important authors must be identified first. Therefore, this paper selects authors who have published no less than 40 co-authored papers, that is, those who have published at least 40 co-authored papers during the 15 years are considered to be relatively important in the co-authored network, so a total of 218 authors are obtained. Then the Python code is used to calculate the number of simultaneous appearances of any two authors in the paper, and the co-occurrence matrix of these 218 authors is obtained. The intercepted part of the matrix is shown in Fig. 3.

Author	Number of papers	Author	Number of papers	Author	Number of papers	Author	Number of papers
Gupta, Rangan	208	de Haan, Jakob	65	Pierdzioch, Christian	55	Gil-Alana, Luis A	48
Rozelle, Scott	133	Zhang, Anming	65	Chang, Hsu-Ling	54	Martinez-Zarzoso, Inmaculada	48
Bahmani-Oskooee, Mohsen	131	Raitagi, Badi H	64	Fanti, Luciano	54	Linton, Oliver	48
Chang, Tsangyao	122	McKenzie, David	64	Lu, Yi	54	Scarpa, Riccardo	48
Smyth, Russell	120	Marjit, Sugata	63	Klasen, Stephan	54	Van Reenen, John	47
Lee, Chien-Chiang	116	Hasan, Iftekhar	63	Li, Qi	54	Loeschel, Andreas	47
Hammoudeh, Shawkat	114	Gueth, Werner	63	Edenhofer, Ottmar	54	Otsuka, Keijiro	47
Zavadskas, Edmundas Kazimieras	110	Tiwari, Aviral Kumar	62	Wang, Ping	54	Narayan, Seema	47
Shahbaz, Muhammad	107	Cromer, Helmuth	62	Afonso, Oscar	54	Yang, Jun	47
Narayan, Paresh Kumar	106	Charness, Gary	62	Zenou, Yves	54	Nishimura, Kazuo	47
Huang, Jikun	101	Yang, Hai	61	Jawadi, Fredj	53	Stiefer, Andrea	47
Belaidi, Hamid	96	Friehe, Tim	61	Zhang, Wei	53	Mulley, Corinne	47
Apergis, Nicholas	91	Bojnec, Stefan	61	Su, Langjun	53	Sunde, Uwe	47
Acemoglu, Daron	89	Whalley, John	61	Boehringer, Christoph	52	Nayga, Rodolfo M., Jr.	47
Nijkamp, Peter	89	Caporale, Guglielmo Maria	60	Sousa, Ricardo M.	52	Kumbhakar, Subal C	47
Su, Chi-Wei	87	Westerlund, Joakim	60	Zhang, Jie	51	Hess, Stephane	46
Hanley, Nick	87	Afonso, Antonio	60	Stark, Oded	51	Agarwal, Sumit	46
Lin, Boqiang	87	Gallegati, Mauro	59	Proost, Stef	51	Wang, Shuaian	46
McAleer, Michael	86	Gerlach, Hans	59	Yang, Chih-Hai	51	Currie, Janet	46
Egger, Peter	85	Zhang, Lei	58	Swinnen, Johan	51	Ryu, Doojin	46
Managi, Shunsuke	78	Park, Donghyun	58	Fafchamps, Marcel	50	Hensher, David A	46
Gibson, John	77	Lusk, Jayson L	58	Kapetanios, George	50	Shogren, Jason F	46
Stroimikova, Dulia	76	Wei, Yi-Ming	58	Weinhardt, Jukka	50	List, John A	46
Mukherjee, Arijit	75	Barros, Carlos Pestana	58	Aghion, Philippe	50	Chen, Xiaohong	45
Wohar, Mark E.	73	Goerg, Holger	57	Becchetti, Leonardo	50	Chevallier, Julien	45
Pestiau, Pierre	73	Martinsson, Peter	57	Brazier, John	50	Houser, Daniel	45
Serletis, Apostolos	73	Rodriguez-Pose, Andres	57	Pesaran, M. Hashem	50	Dustmann, Christian	45
Nunnenkamp, Peter	72	Duc Khuong, Nguyen	57	Belke, Ansgar	50	Morris, Stephen	45
Zilberman, David	71	Dehnnger, Klaus	56	Marcellino, Massimiliano	50	Galiani, Sebastian	45
Dreher, Axel	71	Torgler, Benno	56	Riotveld, Piot	50	Hamori, Shigeyuki	45
Fan, Ying	69	Asche, Frank	56	Wang, Shouyang	49	Karlan, Dean	45
Hensher, David A	68	Strobl, Eric	56	Semmler, Willi	49	Goel, Rajeev K	45
Matsumura, Toshihiro	67	Meng, Qiang	56	Chang, Chun-Ping	49	Harrison, Glenn W	45
Zhang, Lnxiu	67	Taylor, A. M. Robert	56	Philips, Peter C. B	49	Bulte, Erwin	45
Qaim, Matin	67	Muscholl, Oliver	55	Frenses, Philip Hans	49	Carlsson, Fredrik	45
Balcilar, Mehmet	67	Nayga, Rodolfo M., Jr	55	Aizenman, Joshua	49	Grolleau, Gilles	45
Sutter, Matthias	67	Siciliani, Luigi	55	Wu, Chongfeng	48	Larch, Mario	45

Fig 2. Frequency of co-authors publishing co-authored papers (part).

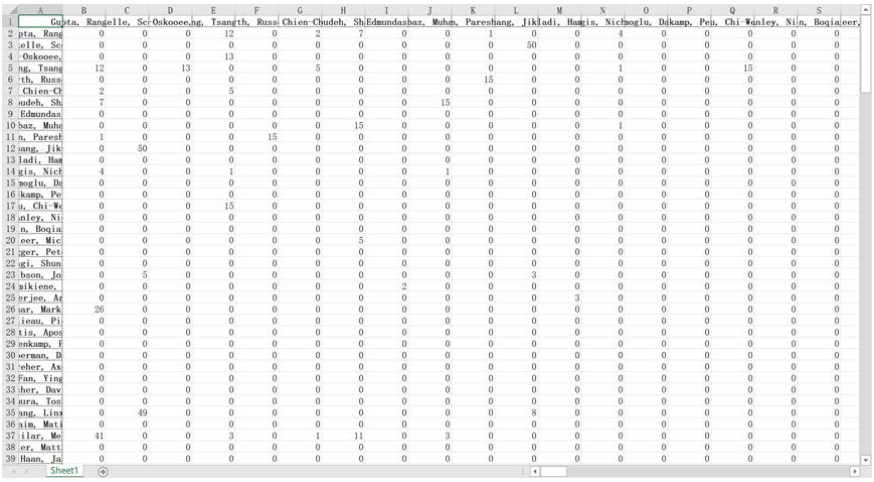

Fig 3. Co-authors co-occurrence matrix (part).

Use Python to visualize it based on the co-occurrence matrix, and get the high-yield co-author network diagram in Fig. 4. In Fig. 4, a vertex represents an author, the size of the vertex represents the

number of co-authored papers published by the author, the thickness of the lines between the vertices represents the number of co-authored times between two authors, and the absence of lines indicates that there is no co-authored relationship. It can be seen from Fig. 4 that Gupta Rangan, Rozelle Scott, Huang Jikun, Bahmani-Oskooee Mohsen and Chang Tsangyao have larger nodes, indicating that their paper output is relatively larger than that of other authors in the network. Scattered along the edge of Fig. 4 are seven scattered dots such as Heywood John S, Grolleau Gilles, Gersbach Hans, Sunde Uwe, Sandler Todd,Zhang Anming and Proost Stef who have not worked with other prolific authors (of course, this does not preclude them from working with authors who have co-authored less than 40 papers). We refer to these seven authors in Fig. 4 as "single-point subnets" [6].

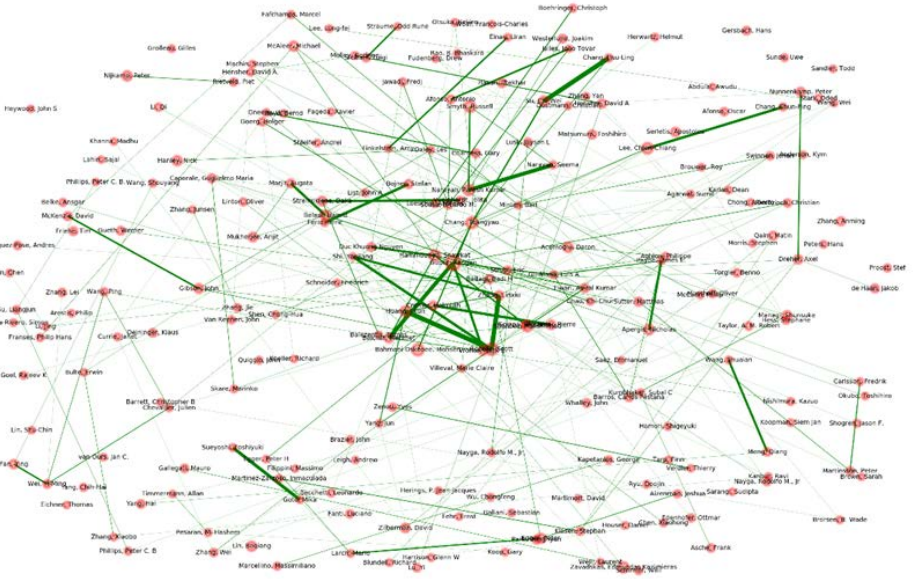

Fig 4. Network diagram of high-yielding co-authors.

We can also see from Fig. 4 that the three authors Shi Yaojiang, Zhang Linxiu and Rozelle Scott have formed an obvious triangular structure of co-authoring relationships. Among them: Rozelle Scott is a professor and senior researcher at the Asia-pacific Research Center of FSI International Institute at Stanford University. His main research directions are: agricultural policy analysis, rural resources and poverty economics; Zhang Linxiu is the deputy director of the Agricultural Policy Research Center of the Chinese Academy of Sciences, mainly engaged in poverty and rural development research; Shi Yaojiang is a professor at the Institute of Educational Experimental Economics of Shaanxi Normal University. He is mainly engaged in the research of rural education intervention in Northwest China. It is not difficult to see that the three authors have intersections in their research fields, namely, poverty in rural China, children's health and education. The small team has co-authored 22 articles from 2011 to 2018. The research areas are all rural areas in China. The research topics cover the impact of parents' absence on the education of left-behind children, the influence mechanism of early financial aid for poor students and other education issues in poor areas, as well as the rural public system construction issues such as project design, village governance and infrastructure quality in China's rural areas. From Zhang Linxiu’s personal resume, we can know that She went to Stanford University as a visiting scholar from March to April in 1997, and probably got acquainted with Rozelle Scott, who is now a chair professor of Yangtze River Scholars at Renmin University of China. The collaborative research between the two authors is more convenient geographically. Similarly, Zhang Linxiu who has served as an adjunct professor at the School of Economics and Management of Northwest University, Xi’an since 2011, has served as an adjunct professor at the Institute of Educational Experimental Economics of Shaanxi Normal University since 2014, had the opportunity to achieve more academic cooperation with Shi Yaojiang, who used to be a professor at the School of Economics and Management of Northwest University and is now a professor at the Institute of Educational Experimental Economics of Shaanxi Normal University due to the overlap of work units and institutions. Similar to authors such as Zhang Linxiu who play a bridge role in the network of co-authors, Yu Fengmin et al. [6] call them

"bridge authors" and they play a crucial role in promoting the scientific research cooperation between different scholars and institutions. At the same time, it can be seen from the key position of "bridge authors" in the co-author network that extensive talent flow is also particularly important for the formation of the co-author network. These authors extend the academic influence of the author and the institution to other institutions through personnel transfer, visiting scholars, and the employment of part-time researchers in the research institution, thus providing an opportunity for the formation of a larger co-author network.

In addition to the above two subnets, there are also co-author pairs with a thicker connection between two points, that is, a higher frequency of collaboration, such as Ferto Imre and Bojnec Stefan. Ferto Imre is a scholar of the Institute of Economics of the Hungarian Academy of Sciences, and Bojnec Stefan is a scholar of the School of Management of Primorska University in Slovenia. The two authors jointly participated in the "The impact of agricultural policy on farm income risk: a Hungarian-Slovenian comparison" project to jointly study the similarities and differences between the impact of agricultural policy on agricultural regional adjustment in Hungary and Slovenia. From 2007 to 2019, they have published 32 co-authored papers, among which the research topics covered agricultural income of Hungary and Slovenia, influencing factors of agricultural trade, agricultural export of EU countries and so on. Thus it can be seen that problem-solving academic teams formed to solve major problems in social development such as economic field also occupy an important position in the co-authored network, and research project tackling is also an important reason for the formation of the co-authored network. In Fig. 4, Su Chi-wei, Chang Hsu-ling, Payne James E and Apergis Nicholas etc. are also typical two-person co-authored subnets.

Fig 5. High-yielding co-author Pajek cluster diagram.

Through the network diagram of high-yielding co-authors visualized in Python, we can only analyze the characteristics of the co-authors network of high-yielding authors with some special points with large nodes and thick links. In order to understand the distribution of small groups of authors in the context of co-authoring, Pajek was used in this paper to cluster the co-authors [7]. The method of operation is to convert the co-author co-occurrence matrix above into a .net file and import it into the Pajek program after simple data processing, and use 218 authors as vertices, and the co-authoring relationship is represented by arcs. Complex networks are generated and clustering is achieved through the Layout--Energy--Kamada-Kawai control provided by Pajek. The results are shown in Fig. 5.

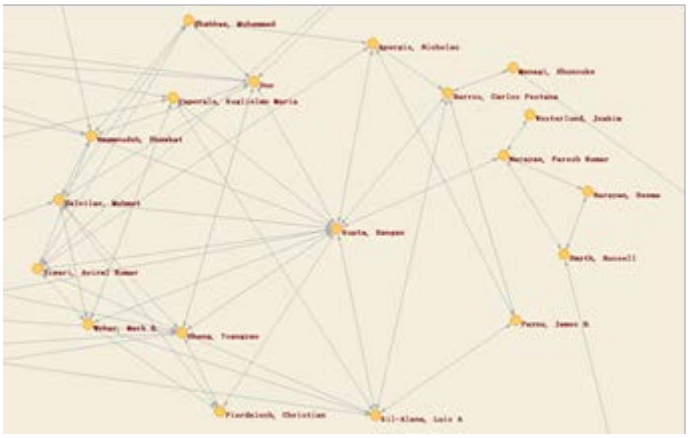

Fig 6. Partial Details of Complex Networks-Take the small team co-authored by Gupta Rangan as an example.

Due to the huge amount of co-authored association data formed by many nodes, within the limited display space can lead to chaos image overlap, poor visual effect. In order to better introduce and explain the constructed network, this article selects Gupta Rangan, the author with the highest frequency of co-authoring, as the central node, a partial detailed diagram of the network is constructed for the 13 nodes that have a co-author relationship with him and the relationship between these nodes, as shown in Fig. 6 (for clarity, the position of the nodes has been manually adjusted, and the weights on the edges have been omitted). In Fig. 6, the dots represent the author and are identified by name. The grey line indicates the co-authorship between authors. The more leads connected to a node, the higher the co-authoring frequency of the node author. In order to show the coauthor's network relationship more clearly, the node position was manually adjusted. It can be seen from Fig. 6 that Gupta Rangan has the highest co-authorisation frequency in the network diagram, so we selected his co-authorizing team to conduct a simple co-authorizing network analysis. In Fig. 6, Gupta Rangan's team consists of 13 authors, they are Apergis Nicholas, Duc Khuong Nguyen, Caporale Guglielmo Maria, Hammoudeh Shawkat, Balcilar Mehmet, Tiwari Aviral Kumar, Wohar Mark E, Chang Tsangyao, Pierdzioch Christian, Gil-alana Luis A, Narayan Paresh Kumar, Barros Carlos Pestana and Lee Chien-Chiang. Among them, Gupta Rangan is a scholar in the Economics Department of the University of Pretoria. His main research direction is macroeconomics and monetary policy. Balcilar Mehmet is a professor of Econometrics at the Eastern Mediterranean University. He was a special professor at the School of Economics of the University of Pretoria where Gupta Rangan worked in August 2014, when the two authors may have established an academic connection. Gil-Alana Luis A and Gupta Rangan participated in the "Unit Root and Fractional Unit root/Integration processes" research project of the Interdisciplinary Statistical Analysis Laboratory of the University of Ibadan, thus establishing academic cooperation links. It can also be seen from Fig. 6 that there will be academic cooperation between authors co-authoring with Gupta Rangan, and there are more "bridge authors" in the team, which also helps small groups to connect to form a larger co-author network.

3. Research conclusions and implactions

From the above analysis, it can be seen that extensive and frequent talent flow is critical and important for the formation of a larger and broader co-author network. These high-yield authors have reached co-authoring cooperation with scholars in the same or similar fields through personnel transfer. Or get acquainted with scholars from universities or research institutions in different regions through the experience of visiting scholars, and develop from short-term co-authorship to long-term academic research partners in a certain topic or research direction. Or to extend the academic influence of oneself or the institution to other institutions through the opportunity of part-time researchers in each research institution, so as to achieve long-term research cooperation. Or by working together with other scholars on a major scientific research project, thus accumulating contacts and cooperation

experience, and expanding the application to further research on similar or related topics. Or a group of loosely organized co-authors spontaneously organized around a common interest or point of view. In addition, the intermediary role of the "bridge author" in the team is of great significance to the expansion of the co-authoring network of each team, and the expansion of the breadth and depth of the research content.

By analyzing the co-authorizations of the economics literature in the SSCI database, we can see that more extensive and in-depth cooperation is still the development direction of academic research. More extensive and frequent talent flow, such as visiting scholar experience, part-time scholars concurrently serving as related academic institutions, communication and exchanges among participants of domestic and international academic conferences, joint research on major scientific research projects, and sincere cooperation between classmates and colleagues, etc. This makes the development of the co-authoring network of scholars' papers more extensive and in-depth. The academic community should be encouraged to actively strengthen scientific research cooperation such as interdisciplinary cooperation, inter-institutional cooperation, cooperation between teachers and students, and global cooperation to promote disciplinary exchanges and development.

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