Collaboration of Chinese Scholars in International Articles: A Case Study of Knowledge Organization†

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Abstract: With the development of Chinese education, more and more Chinese scholars pay attention to inter-departmental, inter-regional and even international collaboration, and publish more high quality articles. Exploring the collaborative situation of Chinese scholars in international articles will help Chinese scholars to understand the international collaborative situation. This paper selected international articles published by Chinese scholars in knowledge organization from WOS™ as research object, then from three aspects, seven angles, analyzed the collaborative situation of Chinese scholars. And it finds that both the accumulative number of articles and the accumulative number of co-published articles show exponential growth trend, and the collaborative rate of Chinese scholars rises from 50% in 1992 to 92.53% in 2016. Besides, the collaborative size is 2-5 authors. More importantly, higher collaborative size appears with time. Those further indicate the importance of scientific collaboration. Chinese scholars co-publish articles with more and more nations or regions, however 20% top nations or regions have more than 78% co-published research articles with Chinese scholars. It not only reflects that the capacity of Chinese scholars' academic collaboration and academic exchange is growing over the years, but also reflects that the collaborative nations or regions with Chinese scholar are concentrated.

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1.0 Introduction

The increasingly interdisciplinary, complex, and costly characteristics of modern science encourage scientists to get involved in collaborative research (Lee and Bozeman 2005, 2). Besides, scientific collaboration will help expand the field of disciplinary research, share scientific resources, reduce research risks and produce more high-level scientific researches (Yan et al. 2011, 1). Therefore, scientific collaboration has become one mainstream way of academic research. And, the studies of collaborative problems, which include collaborative motivation, collaborators, collaborative activities, have been attracted many scholars and gradually become hot research content.

Katz and Martin (1997) believed that there were six levels of collaboration: individual, group, department, institution, sector and nation. However, some scholars had different expressions. They divided collaborative research into three levels: the collaboration among nations (macro level), the collaboration among institutes (meso level) and

the collaboration among authors (micro level) (Glanzel 2002; Kretschmer 2004; Taba et al. 2015; Wei 2012). In this paper, we agree that there are three levels of collaboration (micro-meso-macro level). Macro-level mainly studies collaboration among nations/regions, e.g., the evolution of BRICS (Brazil, Russia, India, China and South Africa) and G-7 countries' international scientific collaboration (Bouabid et al. 2016), the relationship between international collaboration and higher citation potential (Rousseau and Ding 2015). Meso level mainly studies collaboration among institutes (government, university, industry, research centers, library and so on), e.g., the analysis of university collaboration, network and industry collaboration, networks about data mining (Zhang, Lilei and Wang 2012), or the research on the cooperation network of scientific research institutions about electronic commerce (Lu and An 2015). Micro level mainly studies collaboration among authors, e.g., the analysis of co-authorship networks of collaborative cancer research in India (Kshitij et al. 2014), or the research on the evolution and trend of individual scholars' collaboration networks in the field of information systems (Zhai et al. 2014). In this paper, Chinese scholars' international collaborative situation is analyzed from both micro and macro levels.

When it comes to the research of collaborative rate, some scholars have carried out related research. Gazni Sugimoto and Didegah (2012) analyzed the articles in the period of 2000-2010 from the Web of Science™ database, and found that the total percentage of multi-authored publications rose from 69% in 2000 to 78% in 2009. Wei and Li (2014) analyzed the Chinese core journals published from 2004 to 2013 in the field of library and information science, and found that the collaborative rate rose from 34.81% in 2004 to 54.36% in 2013. These two sets of data further illustrate the importance of collaboration.

With the development of Chinese education, more and more Chinese scholars pay attention to inter-departmental, inter-regional and even international exchange and collaboration, and publish more high quality articles, which are included in the SSCI, SCI, etc. What is the collaborative situation of Chinese scholars in international articles?

Knowledge organization is found at the intersection of information retrieval and social dynamics. It is seen as the process of structuring of knowledge that borrows from logic, psychology, linguistics, semiotics, epistemology, and informatics (Smiraglia 2014a, 40). Knowledge organization is critical for the proper functioning of the science of information. Without that which is learned in KO, information retrieval cannot work (Smiraglia 2014b, 3). This shows the importance of knowledge organization. Therefore, the quantitative analysis of the literatures related to knowledge organization will help to discern the current collaborative situation of knowledge organization and promote the development of knowledge organization research.

In this paper, the Web of Science™ Core Collection was selected and regarded as the source of international articles in knowledge organization. By limiting conditions, we obtained the data for which the address field contained "Peoples R China." Through the analysis of the acquired data, Chinese scholars can understand the collaborative situation of Chinese scholars in international articles. Then through cooperation and exchange, Chinese scholars can publish more international high-quality articles in order to promote the development of knowledge organization with foreign scholars.

2.0 Data and method

The Web of Science™ Core Collection (2016) provides researchers, administrators, faculty, and students with quick, powerful access to the world's leading citation databases. Authoritative, multidisciplinary content covers over 12,000 of the highest impact journals worldwide—including open access journals—and over 160,000 conference proceedings. It has current and retrospective coverage in the sciences, social sciences, arts, and humanities, with coverage dating back to 1900. In the Web of Science™ Core Collection, "Advanced Research" was selected, the retrieval queries were "AD= (PEOPLES R CHINA) AND TS= (knowledge organization)," document type was "article," timespan was "1900-2016," and indexes were SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI, CCR-EXPANDED and IC. The date of data collection was May 2, 2017. The resultant dataset contains a total of 1,298 records.

From three aspects, which include articles, authors and nations, and seven angles (shown in Figure 1), this paper explores the collaborative situation of Chinese scholars. The accumulative number of articles reflects the development level of Chinese scholars publishing international articles in knowledge organization. The accumulative number of co-published articles reflects the development level of Chinese scholars who co-publish international articles in knowledge organization. The collaborative rate illustrates the degree of Chinese scholars who are willing to cooperate. The collaborative size indicates the scale of Chinese scholar's teamwork. Nations or regions illustrate those that Chinese scholars are willing to co-publish papers with in knowledge organization. The annual distribution of the number of collaborative nations or regions is used to analyze Chinese scholars' capacity of academic collaboration and academic exchange. The nation-year 2 mode knowledge mapping is used to clearly reflect the re-

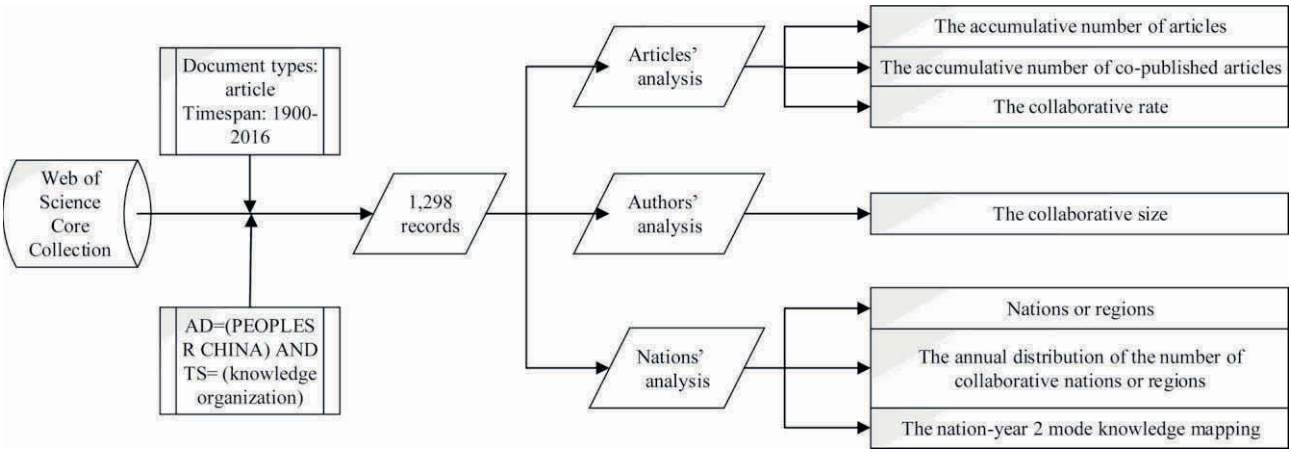

Figure 1. Data processing

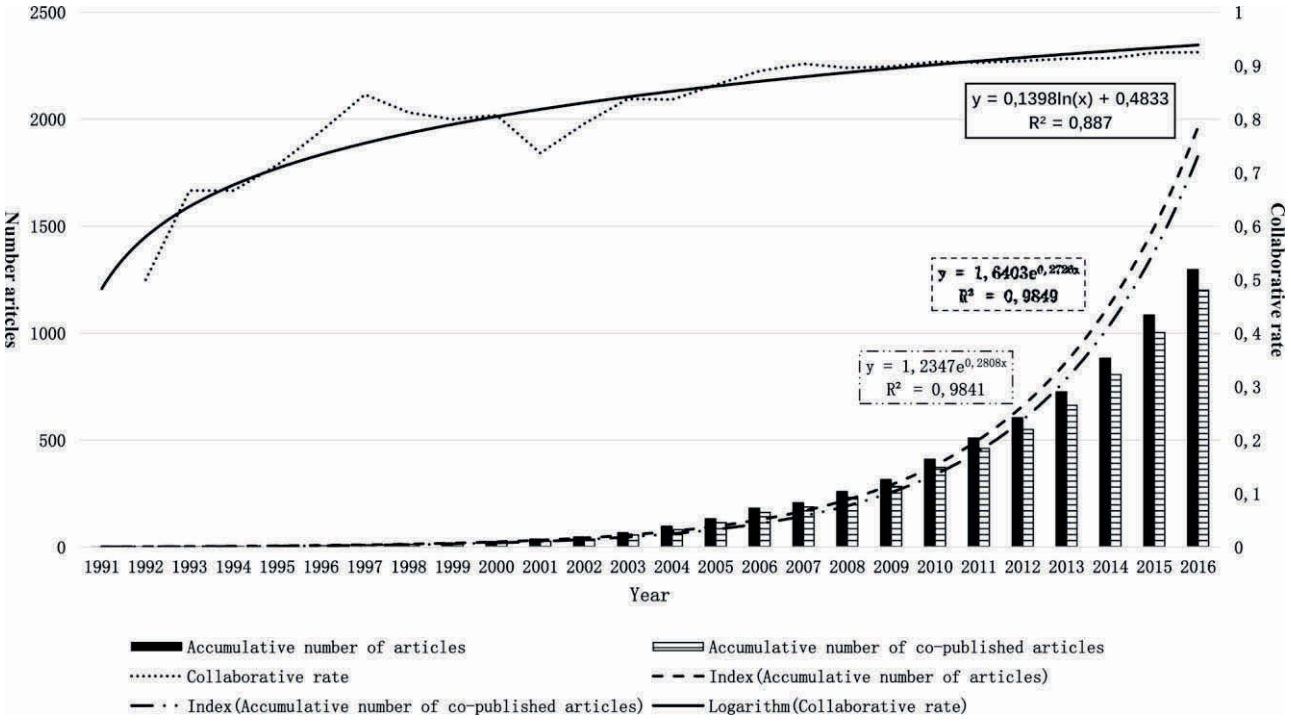

Figure 2. The distribution of the accumulative number of articles, the accumulative number of co-published articles and the collaborative rate of Chinese scholars

lations between the nations or regions, which Chinese scholars collaborate with. The detail data processing flow and analysis process is shown in Figure 1.

3.0 Results

In the 1,298 articles there are 1,201 articles published by two or more authors. The collaborative rate of knowledge organization is as high as 92.53%. It shows that Chinese scholars usually publish international articles via collaborative manner.

3.1 Articles

In order to clearly show the changes of the accumulative number of articles, the accumulative number of co-published articles and the collaborative rate over time, this paper analyzes the three variables over time. The statistical results are shown in Figure 2.

The first Chinese international article related to knowledge organization can be traced back to 1991. In this year, Maris G. Martinsons published *A Domainy1y Selection and Evaluation Framework for Introducing Knowledge-based*

Systems in Smaller Businesses in *Information Systems Journal*. This opens a new era for Chinese scholars, namely the research result of Chinese scholars related to knowledge organization has been recognized by international scholars. And it also indicates two-way exchange and sharing of knowledge between Chinese scholars and foreign scholars in knowledge organization. As shown in Figure 2, the simulated trend line of the accumulative number of articles reflects that the accumulative number of articles shows an exponential growth trend, and meets Place's curve (Qiu 2007). This indicates that Chinese scholars have obtained abundant research results, which are recognized by international scholars in knowledge organization. Besides, the knowledge of knowledge organization in China is rapidly accumulative. Thus, it further promotes the development and process of Chinese knowledge organization. According to the simulated trend line, the accumulative number of Chinese international articles will increase rapidly in the future.

The first international article co-published by Chinese scholars can be traced back to 1992. In 1992, Baodong Li and Zhongzhi Shi co-published *Case Retrieval Based on Memory Network* in *IFIP Transactions, A-Computer Science and Technology* (Li and Shi 1992). Since then, there are more and more international articles co-published by Chinese scholars (by May 2, 2017, there were 1,201 articles published by two or more authors) in knowledge organization. From Figure 2, similar to the simulated trend line of the accumulative number of articles, the accumulative number of co-published articles also shows an exponential growth trend. From the simulated trend line, the goodness of fit is R^2=0.9841. When the goodness of fit is higher, the simulated trend line has higher reliability. This shows that the accumulative number of international articles co-published by Chinese scholars will increase rapidly in the next period of time.

From the distribution of the collaborative rate, the collaborative rate of Chinese scholars has presented a rising trend overall since Chinese scholars first co-published international articles in knowledge organization. The collaborative rate of international articles co-published by Chinese scholars rises from 50% in 1992 to 92.53% in 2016 in knowledge organization. In order to reflect the growth of the collaborative rate, in this paper, the trend line of the distribution of the collaborative rate is simulated, and it finds that the simulated trend line meets the logarithm distribution ($y=0.1398\ln(x)+0.4833$, the goodness of fit is R^2=0.887). The collaborative rate is almost close to 1 in the future. Scientific collaboration is very important in the process of knowledge organization development among the scholars in this study.

3.2 Authors

The collaborative rate of Chinese scholars in knowledge organization is as high as 92.53%. So, what is the size of Chinese collaborations in the international articles in knowledge organization? Has the collaborative size has changed over the years? This section will focus on answering those two questions. In the 1,201 articles, there are 254 articles co-published by 2 authors, accounting for about 21.15%; there are 317 articles co-published by 3 authors, accounting for about 26.39%; there are 218 articles co-published by 4 authors, accounting for about 18.15%; there are 138 articles co-published by 5 authors, accounting for about 11.49%; there are 209 articles co-published by 5-10 authors, accounting for about 17.40%; there are 38 articles co-published by 11-15 authors, accounting for about 3.16%; there are 12 articles co-published by 15-20 authors, accounting for about 1.00%; there are 6 articles co-published by 21-25 authors, accounting for about 0.50%; and there are 9 articles co-published by more than 26 authors, accounting for about 0.75%.

In order to explore the change of collaborative size with time, this study counts the size of collaborations among Chinese scholars in knowledge organization over the years. The statistical result is shown in Table 1. From the table, it can be seen that there has been a change in the collaborative size over the years. The specific performance is as follows: the size of collaborations among Chinese scholars in the international articles in knowledge organization is mainly 2-5 authors in the period 1992-1998. While the collaborative size is also mainly 2-5 authors in the period 1999-2002, in this period fewer articles are completed by 6-10 authors. In the period 2003-2005, the number of articles co-published by 6-10 authors increased notably. Also in this period, articles co-published by 11-20 authors appear. After 2005, the collaborative size is mainly 2-5 authors. Also, the number of articles co-published by 11-20 authors increased notably. Meanwhile, the articles co-published by more than 26 authors appears, e.g., the article *Sharing and Community Curation of Mass Spectrometry Data with Global Natural Products Social Molecular Networking* (Wang et al. 2016) completed by 127 authors. From the above data, it can be learned that the size of collaborations among Chinese scholars in international articles in knowledge organization is mainly 2-5 authors from 1991-2016. More importantly, higher collaborative size appears with time. This further illustrates the importance of collaboration in knowledge organization.

3.3 Nations or regions

In this part, this paper will study the national collaborative situation of Chinese scholars. By statistics, there are

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
2		1					1			1	3	3	6
3				2	1		1	2	1	3	2	4	7
4			1			1	1		1	1		3	1
5						1	1				1		2
6-10									1		1		1
11-15													2
	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
2	10	10	18	4	8	11	24	14	18	23	30	34	35
3	5	9	12	5	20	9	21	25	27	31	37	47	46
4	3	5	6	3	6	12	16	21	15	21	27	38	36
5	5	3	4	5	4	8	5	9	13	15	14	26	22
6-10		4	5	7	5	10	13	14	11	20	27	44	46
11-15	1	1	1	1	1	1	5	4	2	3	6	4	6
15-20	1	1		1			2	1	1			2	3
21-25							1	1	1		2		1
≥26			1		1		2				1	1	3

Table 1. The size of Chinese collaborations in international articles in knowledge organization

Nations or regions	Frequency	Nations or regions	Frequency	Nations or regions	Frequency
USA	290	South Korea	23	Finland	11
Australia	84	France	21	South Africa	10
England	80	Sweden	19	Mexico	10
Canada	48	Brazil	15	Malaysia	9
Peoples R China-Taiwan	40	Italy	15	Denmark	9
Singapore	36	Spain	14	New Zealand	8
Germany	30	India	13	Austria	8
Switzerland	28	Russia	12	Ireland	7
Netherlands	26	Belgium	11	Norway	6
Japan	25	Scotland	11	Lebanon	5

Table 2. The top 30 nations or regions

604 articles finished by authors from two or more nations or regions, which is 46.53% of total collaborative articles. In 604 articles, scholars from 74 nations or regions (the top 30 are shown in Table 2) have been co-published research articles with Chinese scholars in knowledge organization.

From Table 2, according to the 80/20 rule, the 20% top nations or regions have more than 78% co-published research articles with Chinese scholars. It suggests that Chinese scholars are willing to co-publish papers with the scholars of those fifteen nations or regions in knowledge organization. Several factors may explain this phenomenon. First, USA, Australia, England and the other twelve nations or regions have a wealth of teaching resources, excellent educational philosophy and a higher level of education in knowledge organization that attracted Chinese students and even Chinese scholars to continue learning or conduct academic visits. In these nations or regions, Chinese scholars have more opportunities to research together and co-publish their research achievements. Second, scholars or students from the top nations or regions give lectures or study in China, which also in-

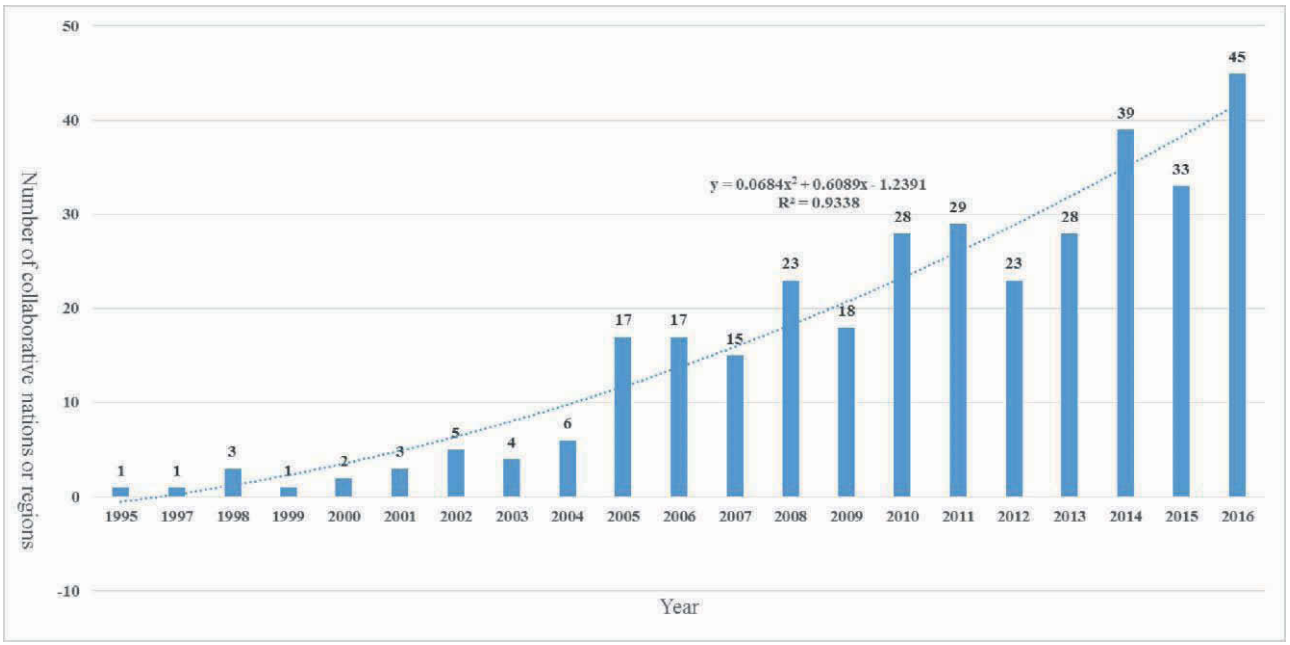

Figure 3. The annual distribution of the number of collaborative nations or regions

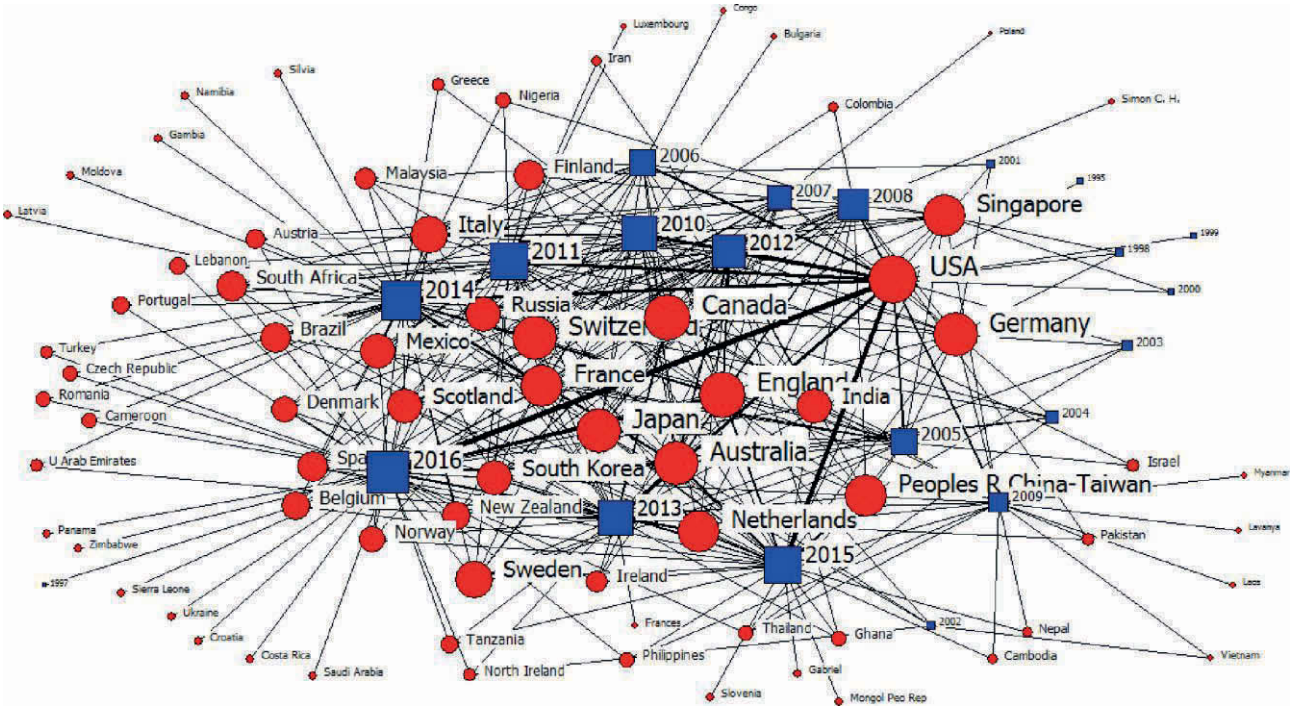

Figure 4. The nation-year 2 mode knowledge mapping

creases opportunities for collaboration. Therefore, there are many articles published by Chinese scholars and scholars from these fifteen nations or regions in Web of Science™ Core Collection.

Next, the annual distribution of the number of collaborative nations or regions is mapped in order to analyze Chinese scholars' capacity foracademic collaboration and academic exchange. From Figure 3, it can be seen that the first Chinese collaborative article with foreign scholar can be traced back to 1995. From the simulation trend line of Figure 3, it can be seen that the annual distribution of the number of collaborative nations or regions of Chinese scholars in knowledge organization presents a quadratic polynomial. After calculation, it shows a growth trend since 1995. This indicates that there are more and more nations or regions with which Chinese

scholars collaborate. And the capacity of academic collaboration and academic exchange of Chinese scholars is growing year to year.

In order to clearly reflect the relations between the nations or regions with which Chinese scholar collaborate, this research maps nation-year 2 mode knowledge mapping. The nation-year 2 mode knowledge mapping is shown in Figure 4. In the nation-year 2 mode knowledge mapping, a square node represents year, and if the node or node's label is bigger, it indicates that Chinese scholars have co-published large numbers of articles in that year; a circular node represents nations or regions, and if the node or node's label is bigger, it indicates that it has a larger degree, namely Chinese scholars have co-published large numbers of articles with this nation or region during past years. The connection line between a square node and a circular node indicates that the nations or regions have a collaborative relationship with China in that year, and if the connection line is thick, it suggests that Chinese scholars have co-published large numbers of articles with the nation or region in that year.

We can interpret the nation-year 2 mode knowledge mapping from two aspects: node and connection line. From the aspect of the node, the 20% top nations or regions are larger in the knowledge mapping. They are core collaborative nations or regions with which Chinese scholar are willing to co-publish papers. The nodes of 2014, 2015, 2016 and other nodes are much bigger, which suggests that Chinese scholars have co-published more articles with foreign scholars in those years. It also reflects in recent years, there are more and more academic exchange among scholars both at home and abroad. This will help the cross-national transmission of knowledge in knowledge organization, then promote the development of knowledge organization. From the aspect of the connection line, in 1995, Chinese scholars and American scholars first co-published an article in knowledge organization, then more and more collaborative articles are co-published, especially in 2014, 2015, 2016 and other years. Compared with the connection lines, the connection lines between the node of USA and the node of year is much thicker than the connection lines between the node of other nations and the node of year. It reflects that USA is the most important collaborator for China.

4 Discussion and conclusions

To explore the collaborative situation of Chinese scholars in international articles in knowledge organization, this paper selects international articles published by Chinese scholars from Web of Science™ Core Collection, then from three aspects and seven angles analyzes the collaborative situation.

Through the analysis of articles, this paper arrives at the following conclusions. Both the accumulative number of articles and the accumulative number of co-published articles show an exponential growth trend. This indicates the development and progress of Chinese education in knowledge organization. In total, the collaborative rate of Chinese scholars in international articles rises from 50% in 1992 to 92.53% in 2016. This indicates scientific collaboration is more and more important in scientific research activities. Therefore, an author who wants to publish articles, especially international articles, seeks collaborators to achieve it together. There are many methods to seek collaborators, e.g., the National Institutes of Health (NIH) RePORTER to identify collaborators for National Library of Medicine information projects (Williams and Rambo 2015), social network analysis to identify potential partners and cooperating agencies (Guo, Li and Liu 2013), and the improved TFIDF algorithm for potential cooperation relationship mining (Hongfei and Wei 2014). These methods provide the possibility of finding a collaborative partner. Then scientific research cooperation becomes a reality.

Through the analysis of authors, the following conclusions are obtained. Overall, the size of Chinese collaborations in international articles in knowledge organization has changed over the years. The collaboration size is mainly 2-5 authors during 1991-2016. And, more importantly, higher collaborative size appears with time. This also indicates that, with the development of technology and society, scientific research gradually has become more integrated and complex. Faced with this dilemma, more and more scholars work together to compensate for the lack of information resources, capital, and technology, then also to maximize the output of scientific research.

Through the analysis of nations, Chinese scholars co-publish articles in knowledge organization with more and more nations or regions (by the end of 2016, it has reached 45), but the 20% top nations or regions have more than 78% co-published research articles with Chinese scholars. Obviously, the collaborative nations or regions have concentration. There are more and more nations or regions that co-publish articles with Chinese scholars. It indicates that the capacity of academic collaboration and academic exchange of Chinese scholars is growing over the years, especially in recent years. We also learn that the national collaborative articles account for 46.53% of total collaborative articles, that is, Chinese scholars pay attention to both domestic collaboration and international collaboration in writing international articles.

More importantly, this present research contributes several perspectives. First, this study proposes an analytical data processing flow of the collaborative situation from three aspects (article, author, nation or region) and seven angles, shown in Figure 1. Second, in this article, we use empirical

methods to analyze the collaborative situation in one aspect of knowledge organization. This provides an example for other disciplines or research fields. In summary, the collaborative situation of Chinese scholars is extremely good in international articles in knowledge organization. Chinese scholars should continue to maintain this trend to make contributions to the development of knowledge organization at home and abroad.

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