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Author bibliographic coupling analysis: A test based on a Chinese academic database

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ABSTRACT

The paper first introduces the basic problems of author bibliographic coupling including the relationship between author bibliographic coupling and document bibliographic coupling as well as the three calculation methods of author coupling strength, namely, simple method, minimum method and combined method. Next I choose a small sample of authors in Chinese library and information science (LIS) as the research objects to have a comparative analysis of three types of author coupling strength algorithms (the data source is from the Chinese Social Sciences Citation Index (CSSCI)). The result shows that the minimum method is the most appropriate one to calculate the author coupling strength. Then a large sample of authors is chosen to analyze the intellectual structure of Chinese LIS. The result shows that author bibliographic coupling analysis (ABCA) can discover the intellectual structure of a discipline better. It is also found that compared with author cocitation analysis (ACA), ABCA has the advantage that it not only can discover the intellectual structure of a discipline more comprehensively and concretely but also can reflect the research frontier of the discipline. Finally, some practical problems that arise during this research are discussed.

1. Introduction

Author bibliographic coupling (ABC) is extended from bibliographic coupling, which refers to the phenomenon that two authors cite the same article(s) in articles that these two authors have published. Based on the assumption of ABC, the more references two authors have in common in their oeuvres, the more similar their research is. The effectiveness of using document bibliographic coupling for research front mining and science mapping has been examined (e.g. Jarneving, 2007; Morris, Yen, Wu, & Tesfaye, 2003). However, there are comparatively less studies on ABCA. White (2001) pointed out that eight information scientists co-cited a large number of the same authors, which shows their common research interests. This is an earlier article that studies the similarity among the authors from the perspective of the author citing. Of course, the idea he proposed in that article is not exactly the same as ABC. Leydesdorff (2011) mentioned on his personal website about some software for ABC, but no related articles are found. Zhao and Strotmann (2008) were the first to propose the idea of ABCA and implemented it in the field of library and information science (LIS), concluding that ABCA can provide supplementary information for studying the intellectual structure of a discipline through authors. Rousseau (2010) did research in calculating the author coupling strength theoretically and proposed a method of calculating the simple coupling strength and the relatively simple coupling strength.

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In China, the ABC was mentioned in some studies, but no empirical study using this method was found. In this paper, I try to explore the following four problems:

- To clarify some basic concepts of ABCA, including the relationship between document bibliographic coupling and ABC, and author coupling strength.
- To compare algorithms of author coupling strength and choose the most appropriate one.
- To test whether ABCA can be utilized for studying the intellectual structure of a discipline based on a Chinese academic database.
- To examine the relationship between ABCA and ACA, and compare their effectiveness for studying the intellectual structure of a certain discipline.

2. Clarification of basic concepts

2.1. Relationship between ABC and document bibliographic coupling

The idea of document bibliographic coupling was first proposed by Kessler in 1963, which was about 10 years before the proposal of document co-citation. Its principle is that the more articles that two articles share in their reference lists, the more similar these two articles are in theme. The two articles are thus called coupled articles, and the relationship between them is called bibliographic coupling. Moreover, sometimes two articles may share more than one article in their reference lists, and the number of articles they share is regarded as an indicator of topic similarity between them, leading to the concept of coupling strength (also called coupling frequency). Therefore, coupling strength is the number of cited articles that two citing articles share. The larger the coupling strength between two citing articles is, the more similar they are.

Bibliographic coupling has been employed in different fields to explore research frontiers, discover domain intellectual structure and retrieve information (Qiu, 2007). Two main features of bibliographic coupling relationship are: (1) the stability of coupling strength, and (2) the demonstration of static relationship between scientific articles (Qiu, 2007). When extending the coupling relationship to author level, these two features are not inherited, i.e. the coupling relationship between two authors is not stable, and the coupling strength between them is changing with time (if either or both of these two authors continue to publish articles). Therefore, document bibliographic coupling is different from ABC in relationship stability: document bibliographic coupling reflects the static relationship between two articles, while ABC relationship can indicate dynamic relationship between two authors.

2.2. ABC strength

As mentioned above, the idea of ABC strength is derived from document bibliographic coupling strength, but the calculation of ABC strength is actually a little more complicated. Similar to the idea of author co-citation strength, the raw ABC strength can be obtained in the following three ways. It should be noted that in all these calculations, all authors are taken into account. But, following Rousseau (2010), references of a paper which is completed by two co-authors are excluded. Table 1 is a simple example: article indicates a paper; author indicates the corresponding author(s) of the paper; reference indicates the references of the paper.

The three main methods of ABC strength calculation are as follows.

- *Simple method*. This method treats all the articles cited by articles written by author X as a document set S1, and all the cited articles by author Y as S2, but excludes the references of papers which are co-worked by author X and author Y. Articles cited by each author for multiple times are only counted once for the author. Therefore, the ABC between author X and author Y is the intersection of S1 and S2. Taking A and B as an example, it can be seen from Table 1 that A has 4 unique references (R1, R2, R4, R5), while B has 4 (R1, R2, R6, R7). A further examination of these two sets reveals that there are 2 articles appearing in both sets, thus the coupling strength between A and B is 2 by this method.
- *Minimum method*. This method takes all the cited articles by author X as reference list S1 and all the cited articles by author Y as S2, and similarly excludes the references of papers which are co-worked by author X and author Y. Repeated cited articles may appear in the reference list of each author. The times that each cited article appeared in each reference list are calculated and taken as cited articles' weights in reference lists. ABC strength between two authors can be obtained by

Table 1
An example of ABC.

Article	Author	Reference
Article 1	A, B	R1, R2, R3
Article 2	A, C	R1, R2, R4
Article 3	A	R1, R2, R5
Article 4	B	R1, R2, R6
Article 5	B	R1, R2, R7

Table 2
Detailed information of 12 journals.

Ranking	Name of journal
1	Journal of Library Science in China
2	Journal of the China Society for Scientific and Technical Information
3	Library and Information Service
4	Journal of Academic Libraries
5	Information Science
6	Document, Information & Knowledge
7	Library
8	Library Tribune
9	Library Journal
10	Information Studies: Theory & Application
13	New Technology of Library and Information Service
-	China Soft Science

summing up the minimum number of times that each cited article appears in both authors' reference lists. Taking A and B in table as an example, R1 appeared twice in A's articles, and twice in B's articles: the minimum number is 2 in this case. After examining these references one by one, I sum up all the minimum number of times that each reference appeared in A and B's articles, and obtain that the coupling strength between these two authors is 4.

- *Combined method*. This method also takes into account the repeated references in reference lists, but uses a different algorithm to calculate coupling strength compared with minimum method mentioned above. In this method, instead of taking the minimum number of times that a reference appeared in references lists of two authors, the calculation of each reference's weight is obtained by multiplying the number of times a reference appeared in an author's reference list and that in the other author's reference list together. For example, R1 appeared twice in A's articles, and twice in B's articles, thus the weight of R1 for calculating the coupling strength between them is 2*2 = 4. The final value of coupling strength can be calculated by summing up the weight of each reference in both authors' reference lists. Using this method, the coupling strength between A and B is 8.

According to these principles, the simple method reduces the similarity of research interests between the two authors. The authors will inevitably refer to some repeated papers that can measure the similarity between two authors, which also should be considered. While the combined method exaggerates the similarities to a certain degree between the two authors, and overemphasizes the role of repeated papers. However, the minimum method is in between, which neither ignores nor exaggerates the role of repeated references. So the minimum method seems more appropriate. Later I will compare the three kinds of methods through an empirical study. For more details see Section 3.3.1.

3. Experiments

3.1. Data description

Data used in this paper are collected from CSSCI. Articles published in journals listed in LIS category in CSSCI from 1998 to 2007 were first collected. Of all the journals, only top 10 journals were used for the empirical study in this paper. These top 10 journals are obtained from *A Report on Chinese Academic Journals Evaluation: A Guidance and Ranking of RCCSE Authoritative Journals and Core Journals* released by Research Center for Chinese Science Evaluation (RCCSE) in 2009. Moreover, *New Technology of Library and Information Service* (*ranked as 13th*) and *China Soft Science*[1] (*a journal about multidisciplinary sciences*), both of which are commonly regarded as core LIS journals by researchers, are also included in this paper, resulting into a total number of 12 journals and 18,731 articles published in them. Table 2 displays the detailed information of these 12 journals.

Based on these selected articles, the number of articles that each author has published (article) were obtained by a Java program.

3.2. Methods

The analysis of ABCA is very similar to that of ACA. Generally, we first have to obtain a symmetric matrix indicating the similarity between each pair of authors (original co-citation matrix), then use cluster analysis, factor analysis and multi-dimensional scaling (MDS), etc., to analyze (and also visualize) the matrix to get the result (McCain, 1990). However, how to deal with the original matrix, especially how to calculate the similarity between authors is controversial. Many researchers have put forward their own solutions. Some researchers continued to defend the traditional Pearson correlation coefficient, such as White (2003a); some researchers made use of cosine and other coefficients to replace the Pearson correlation

[1] Articles that do not belong to LIS are removed manually.

coefficient, such as Ahlgren, Jarneving, and Rousseau (2003); and other researchers explored other data mining methods based on the original co-occurrence strength matrix, such as White (2003b). He drew the knowledge map for 120 highly cited authors in LIS using the pathfinder algorithm. In addition, White also pointed out that for pathfinder algorithm, the result proved that using the original co-occurrence strength matrix was more realistic and more persuasive than using the Pearson correlation coefficient.

In this paper, I use the pathfinder method to discover the intellectual structure of LIS in China. The pathfinder is based on minimum spanning tree and the principle of triangle inequality (Schvaneveldt, 1989). It is insensitive to 0 cells and could be more concise and clearer to identify the academic relationships among authors. In addition, for pathfinder algorithm, data are of dissimilarity for default (Schvaneveldt, 1989), while the author coupling matrix is a typical similarity one, so it requires a certain transformation. In this paper, I realize this transformation through "derivative of the coupling strength and then multiplied by 1000". When the coupling strength is 0, I assign value "999,999" to 0 cells uniformly, which means the minimum similarity between the two authors.

3.3. Result

3.3.1. Comparison of the three author coupling strength algorithm

In order to further compare the pros and cons of the three coupling strength algorithm, I select 40 authors who have published more than 25 papers in this decade as the research object. It should be noted that I select only a small sample to analyze in order to compare the three coupling strength algorithm more clearly, not in order to discover the intellectual structure of a discipline. Discovering the intellectual structure of a discipline requires a larger research sample. The results obtained by the three methods are shown in Fig. 1 (simple), Fig. 2 (minimum) and Fig. 3 (combined).

We can see that Fig. 1, obtained based on the simple method, is the messiest graph that has too many connections between authors and is difficult to classify, which is its biggest shortcoming. In addition, it is also found that there is something wrong with the connection among some authors. There are some links among the information retrieval scholar LR Gan and JP Qiu, FC Ma who both study the basic theory and method of information science, as well as LH Fu who focuses on the basic theories of library science and HQ Ma who makes efforts on information policy (five scholars indicated by boxes in the figure), which is unreasonable and does not appear in the diagrams obtained by the other two methods. In addition, we can find that Fig. 2 obtained on the basis of the minimum method is clearer than the former, and the authors can be classified better. As shown in Fig. 2, they are *basic theories of library science*, *digital library research*, *information retrieval and service*,

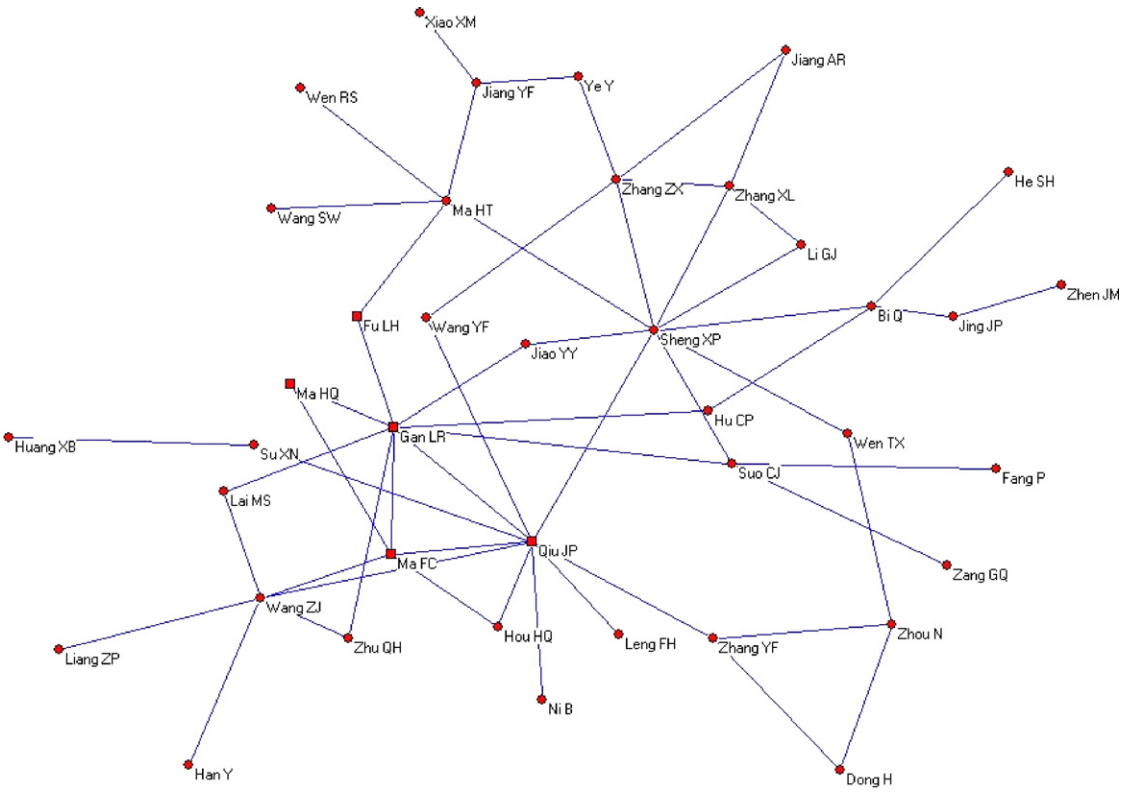

Fig. 1. Mapping of 40 sample authors based on simple method.

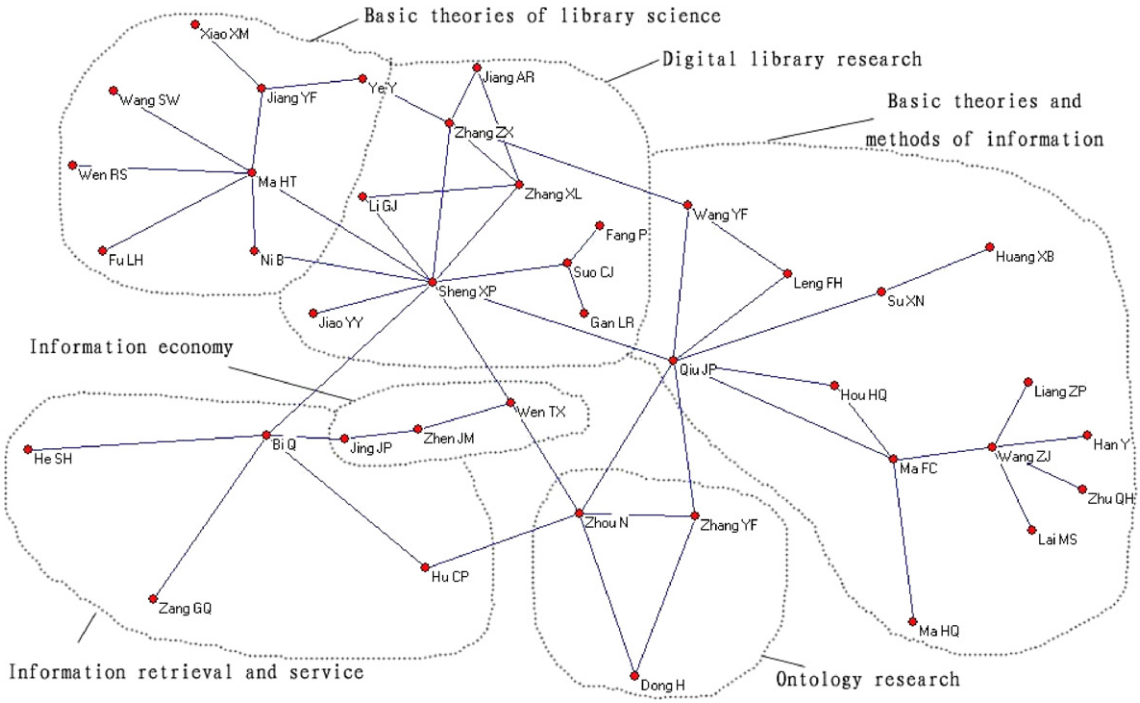

Fig. 2. Mapping of 40 sample authors based on minimum method.

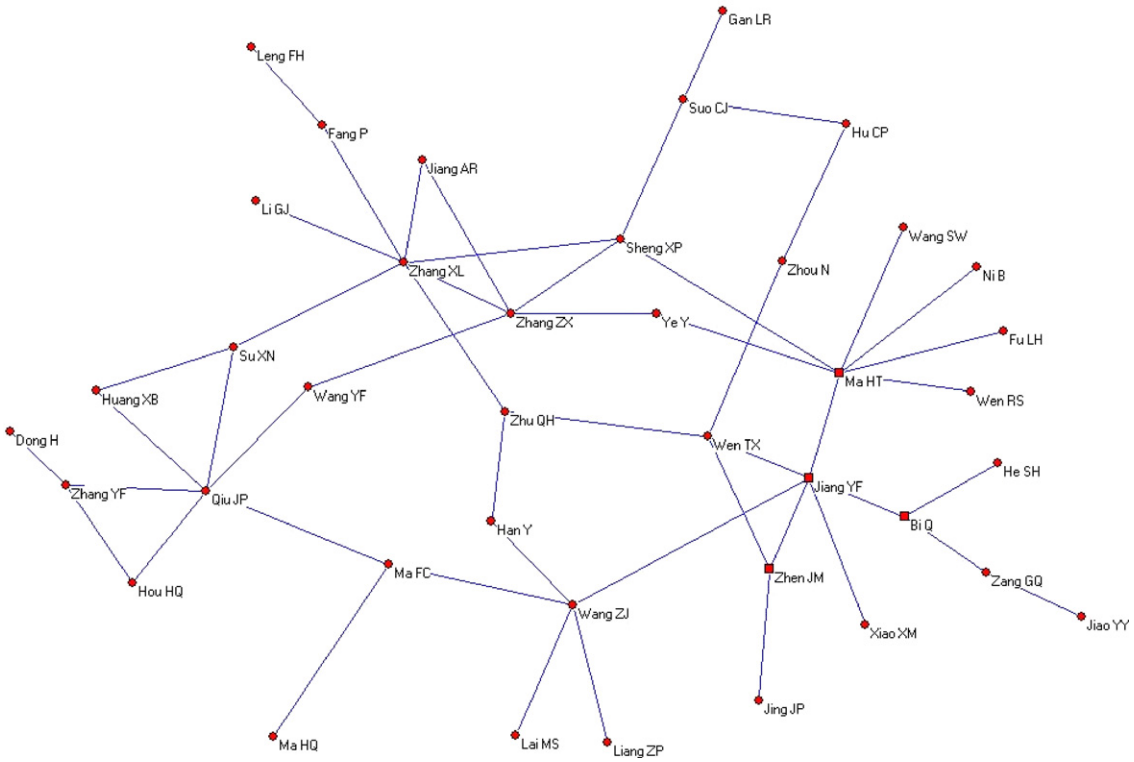

Fig. 3. Mapping of 40 sample authors based on combined method.

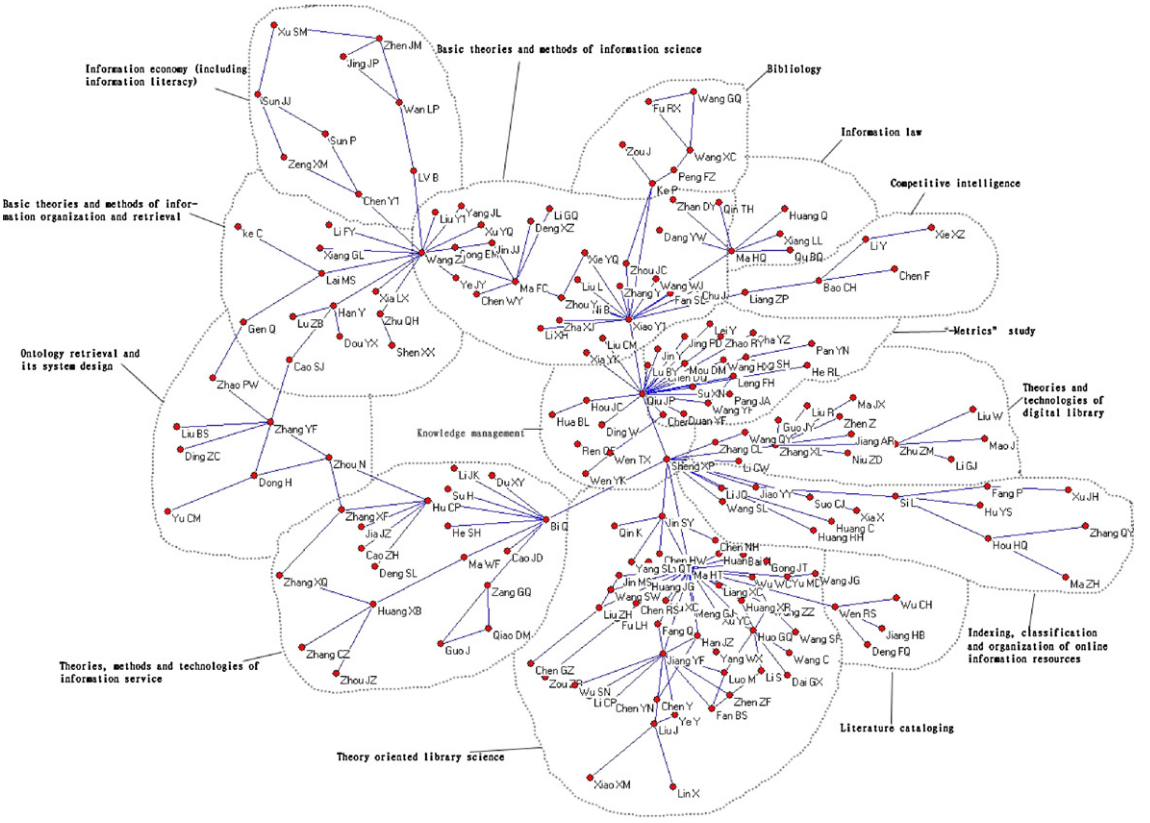

Fig. 4. Mapping of LIS by the method of ABCA (1998–2007).

information economy, *ontology research* and *basic theories and methods of information science*. Lastly, Fig. 3, obtained based on the combined method, is clear, but there are also certain problems in it. There are links among Q Bi, who works on information retrieval, JM Zhen, who devotes himself to the information economy and YF Jiang, who focuses on the basic theories of the library, which is inconsistent with the actual situation, and this phenomenon does not appear in the other two methods.

Combined with the theoretical analysis in Section 2.2 and the comparative study, we may find that the minimum is the most appropriate calculation method of the author coupling strength.

3.3.2. *Discovery of the intellectual structure of Chinese LIS*

Authors who have published more than 10 papers are preliminarily chosen as my research object, leading to a total of 338 authors, and the coupling matrix is obtained by using the minimum method. Furthermore, authors whose maximum coupling strength with each of the other 337 authors is less than 5 are excluded, leading to a set of 195 authors as final research subjects in this paper. The result of ABCA of these 195 authors is also obtained by using the pathfinder method. Fig. 4 displays the detailed information of the 14 sub-fields of LIS obtained through this method, which are shown as follows.

- *Theories, methods and technologies of information service.* This subfield is more technical-oriented, focusing on digital library, organization and representation of online information resource and user centric information system. Q Bi and CP Hu are the two representative authors of this sub-field. This subfield is one of the hot and front topics in LIS.
- *Theories and technologies of digital library*. The subfield is also a comparatively large component of LIS, where XL Zhang and ZM Zhu are the representatives. The subfield contains some researches on information organization and representation of digital library (mainly metadata). The subfield is discussed a lot by LIS community with the development of internet.
- *Indexing, classification and organization of online information resources*. The subfield (L Si is the representative) is the development of traditional information indexing and retrieval, and bears the typical features of LIS. Research in this subfield focuses on the classification and indexing of online information resources.
- *Basic theories and methods of information organization and retrieval*. In this subfield, the scholars MS Lai and ZJ Wang are the representatives. In addition, some scholars have also published related books (e.g. MS Lai published *Introduction to*

Information Retrieval, SJ Cao published *information organization*). Research is mainly about macro aspects and the content is comparatively broad.

- *Ontology retrieval and system design*. This is actually one of the hotspots in the fields of information retrieval, with YF Zhang and H Dong as representatives, including the build standard, principles and methods of ontology as well as the development of ontology retrieval system. With the development of the semantic retrieval research, this study will attract more and more attentions of related scholars.
- *Basic theories and methods of information science*. This subfield consists of some senior researchers in LIS (e.g. FC Ma and ZJ Wang) and focuses on some fundamental theories and methods in information science. The research on this topic is very active, and has achieved some innovative improvement on theories and methods.
- *Information economy (including information literacy)*. This aspect mainly studies the index and method of social informatization measurement, the training, measurement index and method of citizen's information literacy as well as economic policy, with JJ Sun and JM Zhen representing it.
- *Information law*. There are fewer authors in this subfield, and HQ Ma is the representative. Research in this subfield began to burst recently, including information policy and law of information resources and intellectual property.
- *Competitive intelligence*. In this subfield, CH Bao is the representative author. This is a hot topic in LIS during the recent several years, and research outcomes of this subfield have been used to provide support for enterprise competition practice.
- "∼*Metrics*" *study*. This subfield has a large number of authors and JP Qiu is the representative. Authors in this area focus on webmetrics (e.g. link analysis and web impact factor), bibliometric and scientometric study (e.g. journal evaluation and citation analysis). It is an important component in LIS and has been consistently studied a lot.
- *Knowledge management*. Knowledge management has recently arisen in recent years, but focused mainly on knowledge management in library. The study of knowledge management in enterprise environment still needs deep research and practice in the future.
- *Bibliology*. There are also not too many authors in this subfield, and FZ Peng and P Ke are the two representatives. It concentrates on traditional issues of bibliology research and bibliology related education. Bibliology acted as an important role in the history of LIS. Now the task for researchers in this subfield is to fit cataloging into the current era of internet.
- *Literature cataloging*. This research is similar to bibliography, but emphasizes more the principle of the book classification (such as Chinese MARC Research) and its computer realization. RS Wen is the representative.
- *Theory oriented library science*. This subfield consists of a large amount of authors and GQ Huo, HT Ma, and YF Jiang are the three representatives. The detailed research in this subfield includes public library service, library user study, philosophical library study, which are actually mixed and hard to distinguish. But all of these tend to focus on basic library theory studies.

Based on the above analysis, we conclude that ABCA can reveal the intellectual structure of LIS, and thus may provide a new way of studying disciplines.

3.4. A comparison with author co-citation analysis

For years, ACA has been proved to be an effective method for studying intellectual structure of a discipline (Ma & Song, 2006; Zhao, 2008). This study also indicates that ABCA is also a good way of revealing the intellectual structure of a discipline. Then, what is the relationship between these two methods? Which one can explore the intellectual structure better? To answer these questions, a comparison between the results obtained through ACA and ABCA was conducted. Fig. 5 displays the result by ABCA (left-side) and by ACA (right-side, data source and time span are the same as ABCA).[2]

From the perspective of the subfields obtained by both methods, we can see that ABCA results in 14 sub-fields, while ACA 10. Similar sub-fields obtained from two methods are linked by lines in Fig. 5, and we can see that most of the subfields, though obtained through different methods, can be matched. However, we also see that there is a certain distinction between the results obtained by the two methods. In the figure, I use underscores to highlight the two different research directions. Overall, the directions obtained by ABCA are more comprehensive and more specific than by those ACA. Firstly, in the figure, the left shows more research directions than the right, such as *information economics*, *literature cataloging* and *ontology retrieval*, which do not exist in ACA. Secondly, the *digital library theories and technologies* obtained by ABCA are more specific than the *digital information resource development* obtained by ACA. Besides, research on information retrieval also divide into three concrete aspects that are the *basic theories and methods of information organization and retrieval*, the *index, classification and retrieval of network information resources*, and *ontology retrieval* in the results obtained by ABCA, which also indicates that its results are more specific than that of ACA. It should be noted that there is one more subfield in ACA result, namely information resource management. In fact, the research in this subfield is mixed with that in the subfield of basic theories and methods of information science, and authors in both subfields have the similar backgrounds.

It can be observed from Fig. 5 that the results obtained by ABCA reflect the research frontier of a discipline better, such as the subfield "information indexing and retrieval" in ACA result is named "indexing, classification and retrieval of online information" in ABCA; "Ontology retrieval and system design" is undoubtedly a hot topic of current research but it has not been reflected in ACA. Information economics research, especially informatization measurement and information literacy

[2] For results on ACA I refer to Ma (2009).

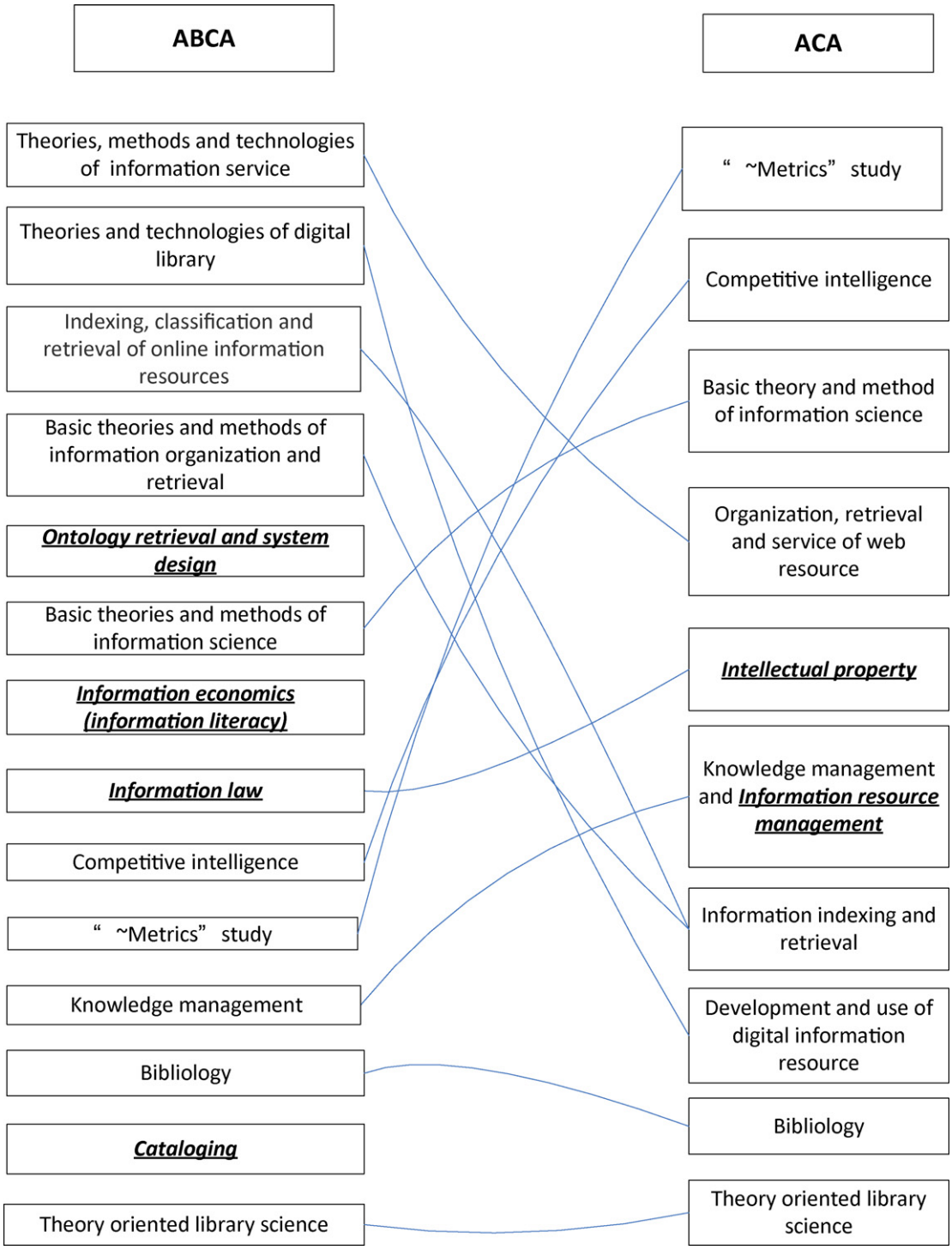

Fig. 5. Comparison between the result of ABCA and that of ACA.

measurement have attracted many LIS scholars, and publish many papers, which also has not been reflected in ACA; literature cataloging has always been the focus of library scientists, which is also not reflected in ACA. All these differences indicate that the result obtained by ABCA seems to reflect the frontier of the discipline better.

Therefore, ABCA can reveal the intellectual structure of a discipline. It provides a more comprehensive and concrete analysis of the intellectual structure of a discipline and can reflect the research frontier of the discipline, while research

directions obtained by ACA are relatively macroscopical. Therefore, I think that ABCA is superior to ACA in exploring the intellectual structure, especially the front structure of a discipline.

4. Discussion

For an exploratory study, there are some more issues that require attention in the future.

4.1. Possible influencing factors of ABCA

The coupling relationship between two authors is not constructed by accident, i.e. it is very less likely that two authors in two totally different areas are coupled through references. However, it is not necessary that two authors in two similar or related areas are coupled through references. There are some factors that influences the construction of coupling relationship between two authors.

4.1.1. Author bibliographic coupling principle

The first factor that may have impact on coupling relationship is its principle. In ABC, two authors are coupled through the venue of a third party, i.e. the cited article in this case. Therefore, ABC relationship can be determined by factors from these two involvements: authors' publications and articles cited by them. From the perspective of author publication, it is true that authors need to have a certain number of publications in order to have the chance to be coupled with other authors through cited references. Without a certain number of publications, two authors with similar research interests are less likely to be coupled than those with lots of publications. Furthermore, the coupling strength between two authors is based on the intersection of cited articles by them, which does not rely on one author's publications, but on the probability that two authors co-cite an article or more. Authors prefer to refer to those classic articles (following the norms of the community). However, the number of these classic articles is limited after all. To cite which article depends on author's subjective will and reference behavior, which seems to be arbitrary to some extent. In addition, for ABCA, the common reference selection behavior is decided by only the two authors, while for ACA, it is decided by many other authors, which makes the probability of author cocitation larger than that of ABC. Therefore, a pair of authors is more likely to be co-cited by an article than to be coupled by articles they cite. This could be one of the reasons why, for the same set of authors, ABC strength is on average lower than the author co-citation strength. (At least for my research, this is the case.)

4.1.2. The subjectivity of author citing behavior

The second one is the subjectivity of author's citation behavior. For an author, the citing behavior can be constrained by certain aspects. Article accessibility is a possible constraint for authors to cite articles. Some authors may have access to a large amount of articles, while others may not. Therefore, the overlap between the accessible articles would be the only linkage for coupling relationship between the authors in those two groups. Moreover, authors' preferences for different kinds of articles differ. Some authors may read and cite only the classics, while some may be interested in only newly published articles. Some authors may read and cite only some articles written by someone who they are familiar with, and most authors tend to cite their own works (White, 2001). In addition, White (2001) also pointed out that the citing styles of the authors who had published different kinds of articles vary. Factors mentioned above are also possible to have impact on the ABC relationship and coupling strength.

4.2. The selection of subjects in ABCA

The proper selection of subject in ABCA is fundamental for this method. It is complicated because publications are always of different quality, especially those from different countries and in different languages. In this research, I suggest that the selection of authors can follow the way discussed below.

Author selection for ABCA needs a comprehensive way which may combine different indicators based on the feature of a discipline. For instance, it could be appropriate to select authors based on their publication quantity if publications are from journals indexed in certain databases of "high quality", such as Web of Science. A post-selection of journals from those databases guarantees the quality of publications (e.g. White & McCain, 1998 selected 12 LIS journals as the data source, all of whose impact factors were about 1 or above). What's more, since publications have been reviewed by peers before publication, their quality is reliable to some extent. Therefore, it is reasonable to select authors based on their publications.

However, the selection rules should be different from those of countries that may have some "lower quality" journals in certain disciplines, where publications on most journals are below the average quality. In this case, it could be reasonable if we try to select a set of journals that are thought to be "more important" and then select a set of authors based on their publications on these selected journals. It is also practical to exclude some authors based on other indicators such as h-index, if necessary. Certain authors can also be added according to their publications, expert surveys and even the researchers' own knowledge about the discipline.

4.3. Information visualization

Based on the experience with this research, I would like to discuss some problems that I encountered while analyzing the data of LIS in China.

4.3.1. "0 cells" in author coupling matrix

As suggested by White (2003a), in author co-citation analysis, authors with a certain number of "0 cells" in matrix should be deleted, as matrices with many "0 cells" are not statistically appropriate for cluster analysis and factor analysis. It is possible that there are many "0 cells" in ABC matrix. If we follow ACA solution, a large number of authors may have to be deleted, which will lessen the number of representative authors for ABCA. Therefore, I choose the pathfinder algorithm to analyze the coupling matrix, as it basically seeks the minimum-weight with the triangle inequality principle (Chen, 2003), which results in its insensitiveness to "0 cells".

4.3.2. Problems while analyzing data with the pathfinder algorithm

It is possible that, in ABC network, an author may be coupled with some authors with the same strength, especially when the coupling strengths between authors in a set are not very large. According to the pathfinder algorithm, an author's same coupling strength with some authors means more than one link from the author to other authors in the set, which could result in that we cannot judge which one(s) is(are) the core author(s) in the final result. Moreover, it can also make it difficult to distinguish the author's research interest from others based on the data. Therefore, I suggest excluding those authors whose maximum number of coupling strength with others is not large enough.

4.3.3. The understanding of the "star" in the result

The star authors, or core authors, who we may observe from the pathfinder result, are not those with large impact in a field. They are, in fact, authors who are active in both publishing articles and citing articles. Therefore, the star authors obtained from ABCA may not be as important as those obtained from ACA.

5. Conclusion

This paper first discusses some basic concepts of ABC by clarifying its relationship with document bibliographic coupling and distinguishing different methods of coupling strength calculation. Then I confirm that the minimum method is the most appropriate one to calculate the coupling strength between two authors through choosing a small sample of authors in Chinese LIS as the research object. Next, through the analysis of a larger research sample, it is concluded that ABCA is also effective to explore the intellectual structure of a discipline. A comparison with the result of ACA indicates that ABCA can discover the intellectual structure of a discipline more comprehensively and concretely and can reflect the research frontier of the discipline better, while the results obtained by ACA are macroscopical. So I think to some extent ABCA has more advantages than ACA in discovering the intellectual structure, especially the front structure of a discipline. Finally, I discuss some factors that may impact the result of ABCA, possible rules of author selection and problems of result visualization, in the hope that this paper can provide some references and implications for the future research.

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