Mapping the development of scientometrics: 2002—2008

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Abstract

  The purpose of this article is to use the methods of Social Network Analysis and Science Mapping to make an analysis on the 816 papers published in the international journal *Scientometrics* from 2002 to 2008. This article studied the development of scientometrics and mapped the distribution and collaboration network of countries, analyzed the TOP44 institutions whose paper number >=5 and showed the relationships by a collaboration network, revealed the co-author network to map the collaboration among different authors, mapped the co-citation network to show the major topics that affected the development of scientometrics deeply. The major tools used in this paper were TDA, NWB and Excel.

Keywords

Social Network Analysis, Scientometrics, Sicence Mapping, Co-countries, Co-institutions, Co-authors, Co-citation

1 Introduction

Scientometrics is a distinct discipline that has emerged from citation-based domain visualization. It is the quantitative study of scientific communications, which applies bibliometrics to scientific literature (Börner, Chen, & Boyack, 2003). Scientometrics has been used widely by scientometricians with their particular methods in evaluating the progress of science and behaviors of scientists. After decades of development (Rip, 1997), it used literatures, patents and grants *et al*. as important tools to map the development of many subjects based on the large-scale scholarly datasets and mapping of science technologies now. More and more scientometrics achievements had been made. For example, Börner (2006) discussed the mapping research on structure and evolution of science. Börner, Penumarthy, Meiss, and Ke (2006) mapped the diffusion of information among 500 major U.S. research institutions based on the 20-year publication data set published in the Proceedings of the National Academy of Sciences (PNAS) in the years 1982-2001. Boyack, Börner, and Klavans (2009) mapped the structure and evolution of chemistry research over a 30 year time frame based on Science (SCIE) and Social Science (SSCI). Leydesdorff and Rafols (2009) made a global map of science based on the ISI subject categories. Chen, Fang, and Deng (2008) mapped the world library science Based on SSCI, *et al*.

At the same time, many organizations such as OECD, NSF, NIH use scientometrics methods to evaluate the technology innovation capabilities in different levels of countries, regions or institutions by patents (Chen, Yang, & Fang, 2009) or literatures. For example, OECD has developed new indicators, notably on patent families, citations, to map aspects of the innovative performance and technological progress of countries, regions or certain specific domains and technology fields (OECD, 2009). And ipIQ Inc. helped NSF to do the research on Science and Engineering Indicators (SEI) for some years, in which patents had been analyzed carefully (IpIQ & NSF, 2009). While NSF (Boyack et al., 2009) and NIH (Börner, 2006) had also funded some scientometricians to carry out research on scientometrics.

As scientometrics is so important that there were some works had been done for analyzing scientometrics based on the analysis of papers published in the journal *Scientometrics*. For instance, Schoepflin and Glanzel (2001) found a decrease in the percentages of both the articles related to science policy and to the sociology of science by classifying the articles published in *Scientometrics* in the years 1980, 1989 and 1997. Peritz and Bar-Ilan (2002) analyzed the papers published in *Scientometrics* in 1990 and 2000 and found that Research Policy and Social Studies of Science are the third and fourth most frequently referenced journals in articles published in *Scientometrics*. Chen, McCain, White, and Lin (2002) drew upon citation and co-citation patterns derived from articles published in the journal *Scientometrics* (1981-2001). Hou, Kretschmer, and Liu (2008) analyzed the structure of scientific collaboration networks in scientometrics at micro level (individuals) by using bibliographic data of all papers published in *Scientometrics* of the years 2002-2004. Dutt, Garg, and Bali (2003) made an analysis of papers published by *Scientometrics* during 1978 to 2001 by scientometrics assessment on countries and themes distribution, comparison of institutions and co-authors.

However, there was no work focusing on mapping the panorama of the development of scientometrics in recent years. The purpose of this paper was to deal with it. Since we have no way to get all the information about a subject, we have to circle some

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information, such as literatures, patents, conferences, *et al*. as dataset to study a particular subject. This paper selects the international journal *Scientometrics* as the source to analyze the development and structure of scientometrics for the following reasons: firstly, De Solla Price(1965) suggested that journals would be the appropriate units of analysis; secondly, *Scientometrics* was the flagship journal of the field of scientometrics (Chen et al., 2002) and ranked second (*Journal of The American Medical Informatics Association* ranked First whose impact factor is 3.094 in 2007) in impact factor (1.472 in 2007) among the 63 SSCI journals on the subject of Information Science & Library Science accounted by JCR 2007 (ISI, 2008); finally, according to the work done by (Wilson, 1999), *Scientometrics* was the most familiar journals in the field of informetrics.

With the advancement of Social Network Analysis (SNA) and display capabilities of computers, there has been growing interest in mapping and visualization (Judit, 2008). Börner, et al. (2003) provided an excellent overview of the techniques used in the process of mapping and visualizing knowledge domains. Therefore, this paper will utilize the present techniques to map the structure of Scientometrics from 2002 to 2008 using *Scientometrics* by the methods of SNA and Mapping techniques.

2 Data & methods

A search carried out on the Web of Science for the journal of *Scientometrics* limited to 2002–2008 resulted in 816 items covering all types of literatures published by *Scientometrics*. Data were collected in April 2009. In this paper we calculate, analyze or visualize the *Scientometrics* papers mainly by the tools of Thomson Data Analyzer (TDA), EXCEL and Network WorkBench (NWB) (NWB Team, 2006). This paper mapped the development of scientometrics mainly in three levels: countries (or regions), institutions and authors. Furthermore, co-citations had also been used to get further information on scientometrics. At the same time, this paper is a new application of SNA on literatures analysis.

3 Results

3.1 Country Diffusion & Collaboration

The analysis of 816 papers published in *Scientometrics* during 2002-2008 showed that they were contributed by 57 countries (or regions). The countries (or regions) with more than or equal to 5 papers had been marked in geographic map as shown in Fig. 1, which had clearly illustrated that European countries were the main source of scientometrics papers. Most of the 57 countries were from Europe. Other major countries (or regions) had a larger number of papers were USA and Canada in North America, China, India, Taiwan, South Korea and Japan in Asia, Brasil in Latin America, and Australia. Compared to the report named *Key figures of Science, Technology and Innovation 2007*, published by European Commission, which had shown that the EU is the world's largest producer of scientific output accounting for 38%, while the US for 33%, Japan for 9% and China for 6%. However, in the field of scientometrics, EU countries and China contributed more papers than USA and Japan respectively. Japan had even not appeared in the TOP 10 countries (Regions).

FIG. 1.   Geographic Distributions for the top 31 countries (>=5 papers)

Fig. 2 had clearly illustrated the average annual growth rates of TOP10 countries, from which we can conclude that USA, Belgium, Spain, China and Germany had higher growth rates and India had a negative growth rate. Since the average annual growth rate of the papers published in *Scientometrics* is only 7.7%, all the TOP 10 countries had a much higher growth rate than 7.7% except for India, which means that more and more papers published in *Scientometrics* were from the TOP 10 countries

except for India, and their share was increasing. And other countries including India contributed less and less in terms of paper numbers.

Particularly in China, many institutions had began to pay more attention to research on scientometrics, and some major institutions are Harbin Institute Technology, Beijing University, Henan Normal University, Chinese Academy of Sciences, Tsinghua University, Institute of Science & Technology Information China, Wuhan University, Zhejiang University, Peking University, Shanghai Jiao Tong University and Dalian University of Technology .

From Fig. 3 we could see that all the TOP 10 countries had a higher number of times cited. It indicated that the papers contributed by those countries were of higher quality and had more impact. In order to evaluate the qualities quantitatively, this article introduced a concept of times cited per paper to compare the impact of each country.

Table 1 showed that Belgium was most active in collaboration times, but it only collaborated with 12 countries, while USA and Netherlands had 19 collaboration countries. But USA had only 37 collaboration times. In order to visualize the relative intensity of collaboration, this article introduced the concept of Relative Collaboration Intensity (RCI) indicator. The average number of collaboration countries (CC), average collaboration times (CT) and Relative Collaboration Intensity (RCI) of the 10 countries were given in formula (1), (2) and (3):
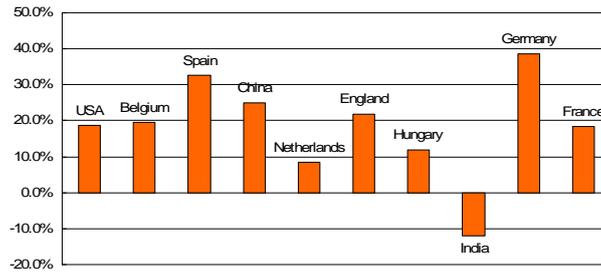

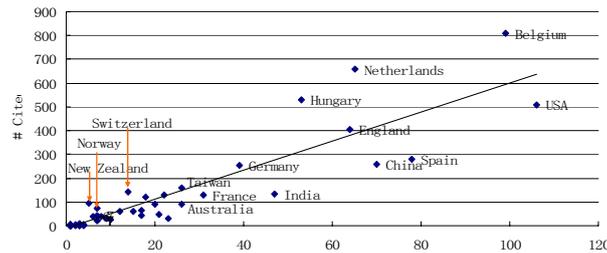FIG. 2.   Average annual growth rates of TOP10 countries

FIG. 3.   # papers and times cited of 57 Countries

The RCI values were listed in Table 1. We found that Belgium had the highest relative collaboration intensity, and England, Netherlands and USA ranked 2, 3 and 4.

$$\overline{CC} = \sum_{i=1}^{10} CC_i \Big/ 10 \qquad (1)$$

$$\overline{CT} = \sum_{i=1}^{10} CT_i \Big/ 10 \qquad (2)$$

$$(RCI)_i = 0.5 \times CC_i \Big/ \overline{CC} + 0.5 \times CT_i \Big/ \overline{CT} \qquad (3)$$

In order to make a clear vision about the collaborations among all the countries/regions (57), the country collaboration network had been made with the method of SNA by NWB. Table 2 listed the network parameters, from which we could see that there were

18 countries that had no collaborations with other countries in *Scientometrics*. The largest connected component in the network had 37 nodes, and there is another small component with 2 nodes. Fig. 4 showed the largest component with 37 countries, which depicted that Belgium, England and Hungary had formed an strong connection. The largest connection lied between Belgium and Hungary, and the collaboration times were 27. Fig. 4 also showed that although the USA had the largest number of papers, the collaboration activity was weaker than Belgium, Hungary, England and Finland. USA had paid much more attentions to collaborate with Canada, England and Australia. Netherlands had collaborated with many countries, however, the collaboration times were fewer compared to Belgium, England and Finland.

TABLE 1. TOP10 collaborative countries (List by collaboration times)

Countries	BE	CN	UK	FI	GE	HU	NL	ES	SE	US
CC	12	10	17	7	9	7	19	10	10	19
CT	84	23	51	36	18	40	42	20	17	37
RCI	3.3	1.5	2.8	1.6	1.2	1.7	2.7	1.4	1.3	2.6

Notes: CC- Collaboration Countries Number; CT- collaboration times

BE-Belgium, CN-China, UK-England, FI-Finland, GE-Germany,

HU-Hungary, NL-Netherlands, ES-Spain, SE-Sweden, US-United States of America.

TABLE 2. The parameters of Country (Region) collaboration network (all countries)

Network Parameters	2002-2008
Number of Countries(Nodes)	57
Isolated nodes	18
The largest connected component,nodes	37
Edges	102
Edge attributes:Max	27
Edge attributes:Mean	2.38
Average Degree	3.58
Density	0.06
Diameter	4
Average shortest path	2.19

FIG. 4.   Countries (Regions) collaborations network (37 countries,the largest component showed only. Nodes-larger and darker means having more papers; Edges-thicker and derker means having more collaborations.)

3.2 Institution diffusion, collaboration

Table 3 listed the TOP 44 institutions according to their number of papers (P>=5). The times cited of each institution were listed in TC column, and then the average times cited per paper had been calculated and the results were listed in TC/P column. The data showed that Katholieke Univ Leuven (Belgium), Hungarian Academy Science (Hungary) and Leiden Univ (Netherland) ranked from first to third both in number of papers and times cited and all of them had a biggish advantage to others. It suggested that the TOP 3 institutions respectively from Belgium, Hungary and Netherland keep ahead in the field of scientometrics. It was interesting to find that although the number of papers ranked first, there were only three institutions from USA in the TOP 44 and their paper output was all 5 to 6. It indicated that many institutions were engaged in the research of scientometrics with fewer output of papers or had more papers on scientometrics published in other periodicals.

In the TOP 44 institutions, ETH (Switzerland) had the highest TC/P, whose average times cited per paper were 17.8. Taipei Med Univ (Taiwan, 17.1), Hasselt Univ (Belgium, 16.5), SYO Finnish Inst Enterprise Management (Finland, 15.6) and Wolverhampton Univ (England, 15.1) ranked from second to fifth. Leiden Univ (Netherland), Royal Netherlands Acad Arts & Sci (Netherland), Univ Sao Paulo (Brasil), Hungarian Acad Sci (Hungary) and Katholieke Univ Leuven (Belgium) ranked from sixth to tenth (called TOP 10 TC/P institutions) .In order to make a quick understanding of how the times cited per paper of each institution affect the later research work on scientometrics or some other scientific fields and whether the more times cited means a higher impact on the development of scientometrics, the following analysis was carried out.

We select the Most-Cited paper (that had the highest value of times cited) of each TOP 10 TC/P institutions and get 10 Most-Cited papers finally. By analyzing their citing papers, we found that the citing papers which had cited the Most-Cited paper of each institution distributed mainly in the fields of information science & library science, computer science, information systems and interdisciplinary applications (ETH (Bornmann & Daniel, 2005); Hasselt Univ (Leo, 2006); SYO (Meyer, Sinilainen, & Utecht, 2003); Wolverhampton Univ (Smith & Thelwall, 2002); Leiden Univ (Glanzel & Moed, 2002); Katholieke Univ Leuven & Hungarian Acad Sci (Glanzel, 2006); Royal Netherlands Acad Arts & Sci (Heimeriks, Horlesberger, & Van den Besselaar, 2003); Univ Sao Paulo (Batista, Campiteli, Kinouchi, & Martinez, 2006), except for Taipei Med Univ (Taiwan)).

When we look into Taipei Med Univ, which held the second highest times cited per paper, its number of papers was only 7 from 2002-2008. Looking into each of the 7 papers, we found that the article with the title of "Citation review of Lagergren kinetic rate equation on adsorption reactions" (Ho, 2004) had been cited 100 times by the end of April 2009 (when articles be archieved), which contributed 5/6 of all the times cited of Taipei Med Univ. The interesting thing is that most of the papers that cited this paper were distributed in Engineering, Chemical, Environmental science and Physical. There was only one citation in Information science & Library Science.

So a conclusion could be made that although an institution did not have many papers or hold the advantage of research activities, it could carry out one or some significant works that had a great impact on the future development of information science & library science. And some research work on scientometrics had also affected the development of some other scientific fields, such as the work of Taipei Med Univ. Nevertheless, the detailed effect of scientometric on the following researches needs more studies.

TABLE 3. TOP 44 Institutions' number of papers > 5

Sn	Institutions	P	TC	TC/P
1	Katholieke Univ Leuven (Belgium)	55	558	10.1
2	Hungarian Acad Sci (Hungary)	46	524	11.4
3	Leiden Univ (Netherland)	25	370	14.8
4	Natl Inst Sci Technol & Dev Studies (India)	21	79	3.8
5	Univ Granada (Spain)	19	84	4.4
6	Univ Amsterdam (Netherland)	17	142	8.4
7	Univ Antwerp (Belgium)	15	145	9.7
8	CSIC (Spain)	14	107	7.6
9	KHBO (Belgium)	14	116	8.3
10	Helsinki Univ Technol (Finland)	13	74	5.7
11	Univ Sussex (England)	13	60	4.6
12	Wolverhampton Univ (England)	13	196	15.1
13	Lorand Eotvos Univ (Hungary)	12	100	8.3
14	Royal Sch Lib & Informat Sci (Denmark)	10	46	4.6
15	Univ New S Wales (Australia)	8	40	5.0
16	Univ Western Ontario (Canada)	8	38	4.8
17	Limburgs Univ Ctr (Belgium)	8	44	5.5
18	Harbin Inst Technol (China)	8	23	2.9
19	Royal Netherlands Acad Arts & Sci (Netherlands)	7	89	12.7
20	Taipei Med Univ (Taiwan)	7	120	17.1
21	Univ Fed Rio de Janeiro (Brazil)	7	51	7.3
22	Univ Nantes (France)	7	48	6.9
23	Isle Man Int Business Sch (England)	7	25	3.6

24	City Univ London (England)	7	65	9.3
25	Australian Natl Univ (Australia)	7	22	3.1
26	Beijing Univ Aeronaut & Astronaut (China)	7	42	6.0
27	Univ Zurich (Switzerland)	7	104	14.9
28	Hasselt Univ (Belgium)	6	99	16.5
29	Drexel Univ (USA)	6	25	4.2
30	Henan Normal Univ (China)	6	38	6.3
31	ETH (Switzerland)	6	107	17.8
32	Fraunhofer Inst Syst & Innovat Res (Germany)	6	17	2.8
33	Bhabha Atom Res Ctr (India)	6	13	2.2
34	Georgia Inst Technol (USA)	6	21	3.5
35	SYO Finnish Inst Enterprise Management (Finland)	5	78	15.6
36	Natl Taiwan Univ (Taiwan)	5	12	2.4
37	Umea Univ (Sweden)	5	50	10.0
38	Univ Western Australia (Australia)	5	15	3.0
39	Univ Pretoria (South Africa)	5	14	2.8
40	Univ Sao Paulo (Brasil)	5	57	11.4
41	Bar Ilan Univ (Israel)	5	42	8.4
42	Indiana Univ (USA)	5	8	1.6
43	Natl Chengchi Univ (Taiwan)	5	6	1.2
44	Univ Politecn Valencia (Spain)	5	4	0.8

To display the collaboration among those TOP 44 institutions, the institution collaboration network had been made by NWB. Then network parameters were listed in Table 4.

TABLE 4. The parameters of Institution collaboration network (TOP44 institutions)

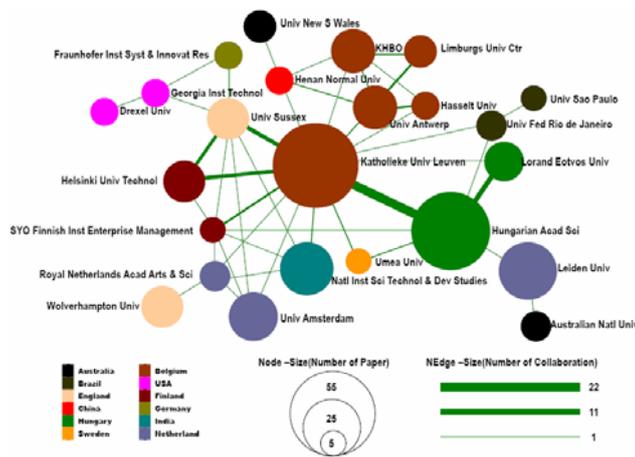| Network Parameters	2002-2008
Number of institutions(Nodes)	44
Isolated nodes	14
The largest connected component,nodes	24
Edges	47
Edge attributes:Max	22
Edge attributes:Mean	3
Average Degree	2.14
Density	0.05
Diameter	6
Average shortest path	2.51

FIG. 5.   Collaboration network of the big Institution collaboration cluster

There was an interesting result that 24 of the TOP 44 institutions collaborated directly or indirectly to form a big collaboration cluster illustrated in Fig. 5. And there were three clusters with two institutions, which were Univ Zurich & ETH, Univ Granada & Univ Nantes, Royal Sch Lib & Informat Sci. The other 14 institutions had no collaborations with the other TOP 44 institutions as isolates. Both of the two institution clusters and isolates were not shown in Fig. 5.

As it vividly showed in Fig. 5 that Katholieke Univ Leuven took up the centre of the cluster with 14 collaborators and most of the nodes were from Europe, especially for the nodes that had more edges. The major countries were Belgium, Hungary, England,

Finland and Netherland. Katholieke Univ Leuven and Hungarian Academy Science had collaborated most during 2002-2008 with 22 collaboration papers. It showed that those two institutions had the most papers, also collaborated most. Hungarian Academy Science had 6 collaborators with one collaboration paper with Leiden Univ (Netherland) which ranked third in number of papers. Both Univ Sussex (England) and SYO Finnish Inst Enterprise Management (Finland) had 7 collaborators and associated with Helsinki Univ Technol (Finland) and Katholieke Univ Leuven (Belgium) to form a firm sub-cluster. Besides Katholieke Univ Leuven, there were four other Belgium institutions which collaborated each other and with Henan Normal Univ (China) to form another sub-cluster.

3.3 Co-Authors Network Analysis

A study carried out by Cunningham and Dillon (1997) for authorship pattern in library and information science indicated that the average number of authors per paper for information science was 1.17. Another study carried out by Dutt et al. (2003) in scientometrics showed that the average number of authors per paper was 1.73 during the period of 1978-2001. We studied the average number of authors per paper published in Scientometrics 2002-2008 and found that the value was 2.29, which indicated that collaboration in scientometrics had been growing since 2001.

To analyze the intensity of co-authorship pattern, the whole data (816 papers) had been divided into two groups, which were single authored (271) and multi-authored (545). Compared to the result made by Dutt et al. (2003) that more than half of the papers were single authored, we found that the ratio of papers written by two or more authors had increased rapidly from 2002-2008.

Having the names of two authors or more listed on one paper is an empirical manifestation of scholarly collaboration. The more often two authors collaborate, the higher the weight of their joint co-author link is. Weighted, undirected co-authorship networks appear to have a high correlation with social networks that are themselves impacted by geospatial proximity (Börner et al., 2006; Wellman, White, & Nazer, 2004) .

In order to describe the collaboration activities of authors, we made the co-authorship networks by NWB. Then network parameters were listed in Table 5. The whole network included one biggest cluster consisting of 199 codes and some smaller clusters, in which author nodes were color and size coded by the number of papers per author. Edges were color and thickness coded by the number of times that two authors wrote a paper together. The remaining commands identify the top-50 authors with the most papers and make their name labels visible. In the top-50 authors, there were 28 authors appeared in the biggest collaboration cluster (shown in Fig. 6).

Table 6 listed the TOP 10 authors according to their number of papers. Compared to Fig. 6 we could find that all the TOP 10 authors were appeared in the biggest collaboration cluster. It was interesting to note that the TOP 10 authors collaborated with each other either directly or indirectly.

TABLE 5. The parameters of co-author network

Network Parameters	2002-2008
Number of authors(Nodes)	1132
Isolated nodes	119
The largest connected component,nodes	199
Edges	1746
Edge attributes:Max	12
Edge attributes:Mean	1.20
Average Degree	3.08
Density	0.003
Diameter	12
Average shortest path	4.74

TABLE 6. TOP 10 Authors

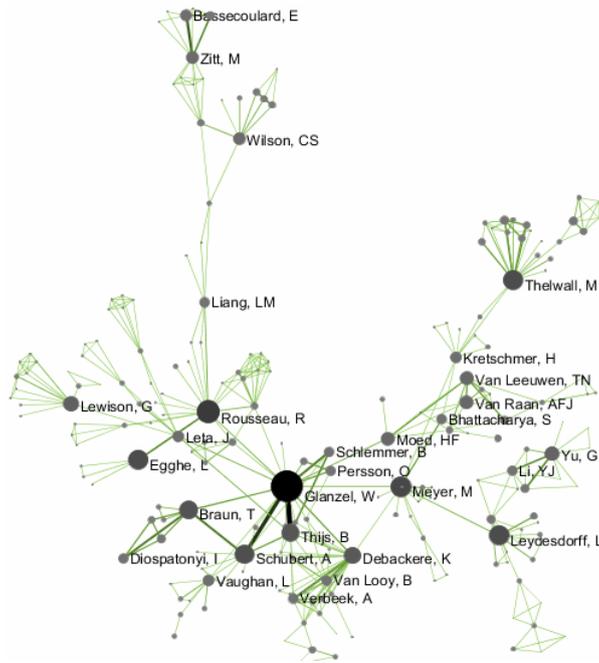| Authors	Number of papers	Times cited	Times cited/paper
Glanzel, W	38	439	11.6
Rousseau, R	21	122	5.8
Meyer, M	17	159	9.4
Leydesdorff, L	16	130	8.1
Thelwall, M	16	202	12.6
Egghe, L	16	149	9.3
Schubert, A	15	162	10.8
Braun, T	14	101	7.2
Thijs, B	13	135	10.4
Debackere, K	12	81	6.8

FIG. 6.   Co-Author Networks of the biggest collaboration cluster (199 authors)

3.4 Document co-citation network

In order to find how many papers had made very important effects on the development of scientometrics from 2002-2008 and which had often been cited together, the cited references had been analyzed to analyze the co-citations of these references which had been cited more than or equal to 5 times by the 816 papers.
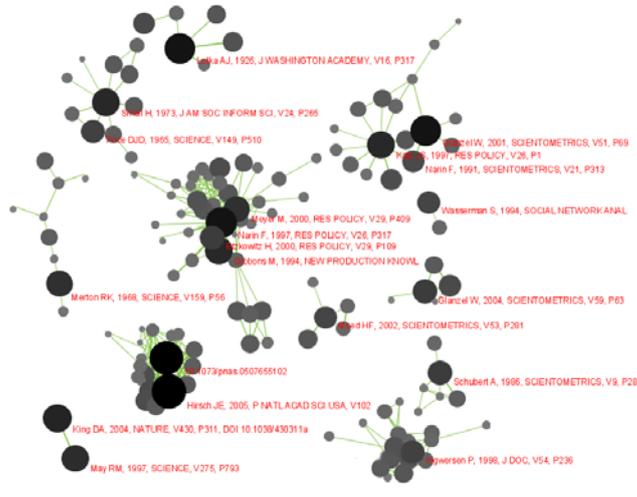

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FIG. 7.   Co-citations network of the cited references (times cited>=5), TOP 20 were marked

Most of the TOP 20 cited references had distributed in big co-citation clusters shown in Fig. 7. The biggest cluster located in the centre had 39 nodes and four of the TOP 20 cited references lied in it. The topics of the four papers were: based patents citing scientific literature to study whether science push technology (Meyer, 2000), the increasing linkage between US technology and public science (Narin, Hamilton, & Olivastro, 1997), The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university-industry-government relations (Etzkowitz, & Leydesdorff, 2000), the new production of knowledge: the dynamics of science and research in contemporary societies (Gibbons, Nowotny, & Limoges, 1994). All these four highly cited papers in the biggest cluster were focusing on the relationship between science and technology especially for the effect of science

on technology. Three of them were published in the journal of *Research Policy* and the fourth is a book. It suggested that the study on the effect of science on technology had affected the study of scientometrics deeply. The second largest cluster contained 19 nodes, two of which were ranked in TOP 20. The topics were about indexes to quantify an individual's scientific research output (Hirsch, 2005). The third largest cluster included three nodes listed in TOP 20, whose topics were about author collaborations (Glanzel, 2001; Katz & Martin, 1997; Narin, Stevens, & Whitlow, 1991). There were another two clusters containing two TOP 20 nodes, and one had 10 nodes, whose topics were on co-citation networks (De Solla. Price, 1965;Small, 1973), the other had only two nodes published in *Nature* and *Science* individually with the topic of the scientific impact and wealth of nations (King, 2004; May, 1997). The other 7 big clusters all had only one TOP 20 nodes within each cluster. The major topic were social network analysis (Wasserman & Faust, 1994), Matthew effect in science (Merton, 1968), author self-citation (Glanzel, Thijs, & Schlemmer, 2004), country research performance (Moed, 2002), evaluation indicators of publication and citation (Schubert & Braun, 1986) and the calculation of web impact factors (Ingwersen, 1998).

The above analysis indicated that the topics about the effect of science on technology, scientific research output indexes, author collaborations, co-citation networks, scientific impact and wealth of nations, social network analysis, Matthew effect in science, author self-citation, country research performance, evaluation indicators of publication and citation and the calculation of web impact factors had affected the study of scientometrics deeply from 2002-2008.

4 Conclusions & discussions

In this paper we analyzed the development and structure of scientometrics and mapped the distributions and collaborations among countries, institutions and authors by SNA methods and citations based on the 816 papers published in the international journal *Scientometrics* from 2002-2008. It was a good attempt to utilize SNA methods on analyzing literatures associated with scientometrics methods, which had been validated that SNA could perform well in the field of scientometrics and library and information science.

When SNA had been applied to analyze the collaboration network, besides the results shown in this paper that EU countries, USA, China and India were the major source of scientometrics papers, more and more papers published in Scientometrics were contributed by those preponderant countries such as the TOP 10 countries. SNA could represent the country (region) collaboration networks, which could show clearly that Belgium, USA, England, Netherlands, Spain, Sweden and China had become the key nodes of collaboration network.

The institution study indicates that Katholieke Univ Leuven (Belgium), Hungarian Academy Science (Hungary) and Leiden Univ (Netherland) , all from EU countries, ranked from first to third both in number of papers and times cited and all of them had a biggish advantage to others. It was interesting to find that although the number of papers ranked first, there were only three institutions of the USA in the TOP 44 and their paper output were all 5 to 6.The reason may be that many institutions had been engaged in the research on scientometrics with fewer output of papers or had more papers about scientometrics were published in other periodicals. It was also interesting to find that the citing papers which had cited the Most-Cited paper of each TOP 10 TC/P institutions distributed mainly in the fields of information science & library science, computer science, information systems and interdisciplinary applications except for Taipei Med Univ, which had been cited most by the papers in Engineering, Chemical, Environmental science and Physical. So a conclusion could be made that although an institution did not have more papers or hold the advantage of research activities, it could carry out one or some significant works that had a great impact on the future development of information science & library science. And some research works about scientometrics had also affected the development of some other scientific fields, such as the work of Taipei Med Univ. Nevertheless, the detailed effect of scientometric on the following research works needs more deep studies on the citing papers of scientometrics papers. This kind of work would be carried out in the near future and could not be provided here.

The institution collaboration network showed that 24 of the TOP 44 institutions collaborated directly or indirectly to form a big collaboration cluster and Katholieke Univ Leuven took up the centre of the cluster.

The average number of authors per paper published in Scientometrics grew faster in 2002-2008 than in 1978-2001. The co-authorship networks illustrated one biggest cluster consisting of 199 codes, and some smaller clusters. In the top-50 authors, there were 28 authors appeared in the biggest collaboration cluster and all the TOP 10 authors were appeared in the biggest collaboration cluster. It suggested that most of the major authors had already developed a direct or un-direct relationship.

Document co-citation network analysis indicated that the topics about the effect of science on technology, scientific research output indexes, author collaborations, co-citation networks, scientific impact and wealth of nations, social network analysis, Matthew effect in science, author self-citation, country research performance, evaluation indicators of publication and citation and the calculation of web impact factors had affected the study of scientometrics deeply from 2002-2008.

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