

# A bibliometric analysis of research on multiple criteria decision making

Dejian Yu, Wanru Wang\*, Wenyu Zhang and Shuai Zhang

*In this study, publications in the multiple criteria decision making (MCDM) field during 1977–2016 were analysed using bibliometric analysis. The statistical analysis of influential publications, journals, countries/territories and authors was first conducted. The developing trends of authors' collaborative structure and research topics were then analysed based on four different periods. The results indicated that more number of publications and authors contributed to MCDM research in the last ten years, and that the collaboration among authors has increased. The comprehensive and scientific analysis of MCDM should help researchers conduct studies in related fields.*

**Keywords:** Bibliometrics, multiple criteria decision making, multiple attribute decision making, social network analysis, VOSviewer.

MULTIPLE criteria decision making (MCDM) has become an important discipline in the field of decision making, since its establishment in the 1950s and 1960s, and subsequent development in the 1970s<sup>1</sup>. MCDM focuses on sufficiently ranking alternatives and finding good ones from a multiplicity of decisions based on multiple criteria, which can help decision makers make decisions gradually. Problems in MCDM can be divided into two types, namely, discrete and continuous problems. Multiple attribute decision making (MADM) methods and multiple objective decision making (MODM) methods focus on solving discrete and continuous problems respectively<sup>1</sup>. MADM methods select the 'best' alternative from a finite number of alternatives based on a series of attributes, whereas MODM methods make decisions from infinite number of alternatives with multiple objectives described by continuous decision variables<sup>2</sup>. Certain studies have dealt with MCDM and MADM together; and use MCDM to represent discrete MCDM<sup>1,3</sup>. In this study, we focus on MCDM and MADM (we use MCDM to represent them both).

Fuzzy MCDM, developed through concepts of fuzzy logic, is an important part of the MCDM field. Zadeh first proposed the concept of fuzzy sets<sup>4</sup>, linguistic variables, and type-2 fuzzy sets<sup>5</sup> to represent uncertain information. Later, a series of related concepts were proposed. For example, Atanassov<sup>6</sup> proposed intuitionistic fuzzy sets; Xu<sup>7</sup> proposed the intuitionistic fuzzy aggregation operator, and Xu and Xia<sup>8</sup> proposed hesitant fuzzy sets. Several studies

have also been conducted on fuzzy sets and aggregation operators<sup>9–15</sup>. MCDM problems under fuzzy circumstances have also been studied<sup>16–19</sup>. Certain important situations require group members to make decisions together. Hence, group decision making (GDM) and fuzzy GDM have also been studied<sup>20–23</sup>. Multi-criteria group decision making based on GDM has also been developed<sup>24–26</sup>.

Since MCDM research has been carried out for more than half a century now, it is necessary to conduct a comprehensive overview of the research in the MCDM field to learn important information or understand the underlying developing patterns. Bibliometric analysis of the MCDM field was therefore conducted in this study. Pritchard<sup>27</sup> introduced and defined bibliometrics as 'the application of statistical methods to the media of communication'. Subsequently, researchers have used bibliometrics based on mathematics and statistics to analyse publications, citations, journals, etc. in many disciplines and fields of study<sup>28–30</sup>. The bibliometric method can be used to analyse number of publications to efficiently find influential publications, authors, journals, organizations and countries. Bibliometrics can also analyse information more intuitively by mapping social networks, such as co-word, co-authorship and co-citation networks. Co-citation<sup>31</sup> is defined as two or more publications being cited by the same publication. Co-word<sup>32</sup> is the co-occurrence of terms extracted from the title or abstract fields of a dataset, so that the research topics can be found. These networks can be visualized intuitively, and various studies have been conducted on bibliometric network visualization<sup>33–35</sup>.

This study aims at analysing publications in MCDM by combining bibliometrics with social network analysis. Based on our dataset and methods, seven questions

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related to MCDM research were analysed in this study. The questions include:

- What is the publishing trend of MCDM related publications?
- Which countries/territories have contributed to MCDM research?
- What are the influential publications in the MCDM field?
- What are the influential journals in the MCDM field?
- Who has contributed to MCDM research?
- What are the changes in the authors' collaborative structures?
- What is the research focus in different periods?

### Dataset and methods

In this study, the dataset was downloaded from the ISI Web of Science (WoS) on 18 August 2017. The search strategy is shown as follows, with the year of publication limited to 2016:

(TS = ('multiple criteria decision-making') OR TS = ('multi-criteria decision-making') OR TS = ('multiple attribute decision-making') OR TS = ('multi-attribute decision-making')) AND DOCUMENT TYPES: (Article OR Review) AND Indexes: SCI-EXPANDED, SSCI.

The search found 4464 publications from 1977 to 2016. For the purpose of this study, the publishing trends of publications were first illustrated. The top influential publications were then introduced based on the total number of citations (TC). Next, the total number of publications (TP), TC, TC/TP of journals, countries/territories and authors were analysed. To explore the developing trends of MCDM research, the period of 40 years was divided into four periods: 1977–1996, 1997–2006, 2007–2011 and 2012–2016. First, the publishing trends of the top 10 productive countries/territories were analysed based on the four different periods. Then the authors' collaborative structure and research hotspots of the MCDM field were analysed based on co-authorship networks and co-word networks respectively.

In this study, the social networks were created using VOSviewer (version 1.6.5, developed by Van Eck and Waltman). According to Van Eck and Waltman<sup>36</sup>, the bibliometric networks visualized by VOSviewer are based on distance, and each network consists of a large number of nodes mapped in a two-dimensional space based on 'visualization of similarities' (VOS). Further, edges can optionally be added between nodes. Each node represents one publication, author or term, etc. The size of the node indicates the co-occurrence or occurrence value and the distance between two nodes represents their approximate relatedness<sup>37</sup>. VOSviewer can also create clusters according to the close relatedness between nodes, and they can appear in different colours in each cluster<sup>36</sup>. In a co-authorship network, the nodes represent the authors,

and edges between authors indicate that they have published publications together; therefore, the authors' collaborative structures are displayed clearly. In a co-word network, one node represents a term extracted from the title and abstract of the publication in our dataset. Study hotspots can be found according to the clusters of all terms. The detailed results are analysed in the next section.

### Results and discussion

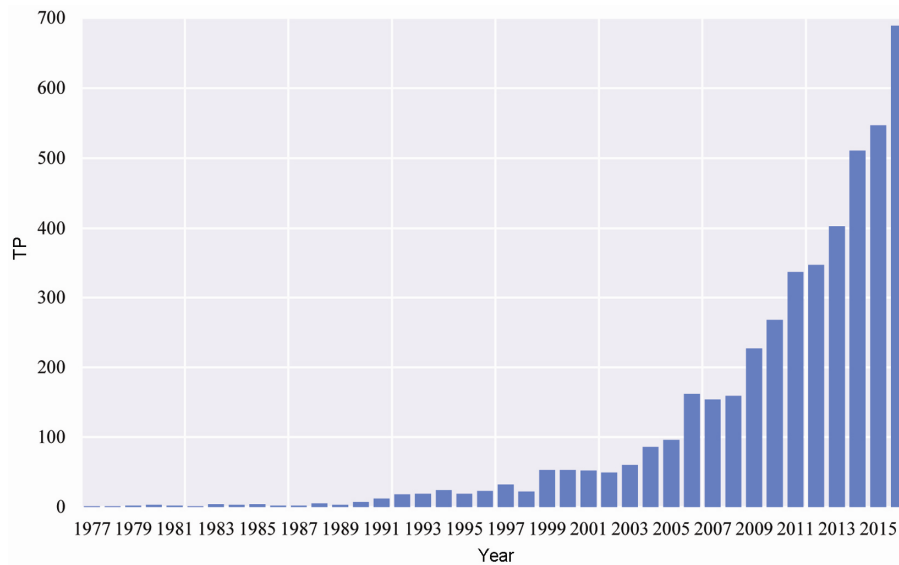
#### *What is the publishing trend of MCDM related publications?*

Figure 1 shows the year-wise frequency of publications and the trend in the number of publications from 1977 to 2016. It is seen that only a few papers were published between 1977 and 1990. After 1990, the number of publications began to increase slightly, and there were more than 100 publications in 2006. Since then, the number of publications per year has rapidly increased, which indicates that MCDM research has received more attention.

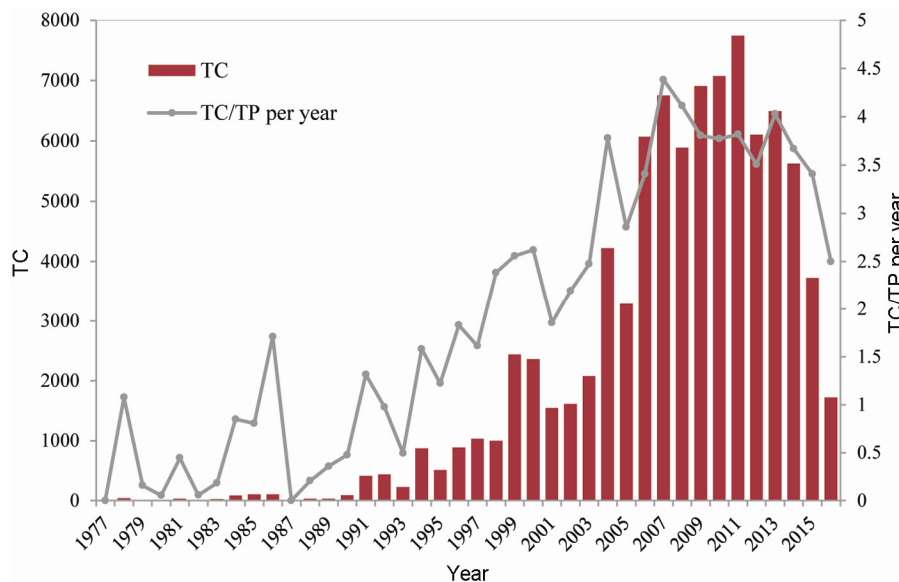
Figure 2 shows the year-wise frequency of citations of MCDM publications and the average citations per publication per year from 1977 to 2016. The number of citations of publications in the period between 2006 and 2014 are more than 5000 each year, with publications in 2011 having the highest number of citations close to 8000. In terms of the average citations per publication per year, the value peaks in 2007 (4.38), which indicates that publications published in 2007 obtained on an average about four citations per year. Besides, the publications between 2004 and 2014 obtained more citations on an average, according to the average citations per publication per year.

#### *Which countries/territories have contributed to MCDM research?*

Figure 3 shows the global distribution of countries/territories of MCDM publications. It is seen that research in MCDM has attracted a lot of attention from the East Asia, West Asia, North America, West Europe and Oceania regions. Table 1 lists the values of TP, TC and TC/TP of the 10 most productive countries/territories. China (including mainland China and HongKong) has 962 publications in our dataset, which lists it at the top based on TP, followed by Taiwan and USA in second and third place respectively. The TC values of China, Taiwan and USA are also listed in the top three. Although China has the most numbers of publications and citations, the value of TC/TP is much lower than most of the top ten productive countries/territories. The publications from the United Kingdom (UK, includes England, Scotland, North Ireland and Wales) have the highest average citations, which is slightly higher than the value of TC/TP of Taiwan, and then followed by Spain, USA and Turkey.



**Figure 1.** Year-wise frequency of publications in MCDM field, 1977–2016.



**Figure 2.** Year-wise total number of citations and average citations per publication per year for MCDM publications, 1977–2016.

Based on the TP of the top ten countries/territories in four different periods shown in Table 1, we can determine the publishing trends of these countries in the MCDM field. In the first 20 years, USA had published 67 publications related to MCDM, which indicates that USA played a leading role in the early development of MCDM research. During the second period between 1997 and 2006, apart from USA, Taiwan, China, and UK began paying more attention to MCDM research. Later, Turkey and Iran began to contribute to the field. In the latest ten years (2007–2016), the number of publications from Taiwan and China has significantly increased. China has risen to 719 between 2012 and 2016, which is three times higher than the number of publications from Taiwan and

USA. Moreover, the number of publications of Iran, Turkey, India, Spain and Lithuania shows clear growth.

#### *What are the influential publications in the MCDM field?*

To determine the most influential publications in the MCDM field, we listed the basic information, TC, and citations per year of the top 30 most cited publications ranked according to TC in Table 2. It is seen that the top three publications were by Opricovic and Tzeng<sup>38</sup> with 834 citations; Herrera and Herrera-Viedma<sup>39</sup> with 729 citations; and Vaidya and Kumar<sup>40</sup> with 718 citations in

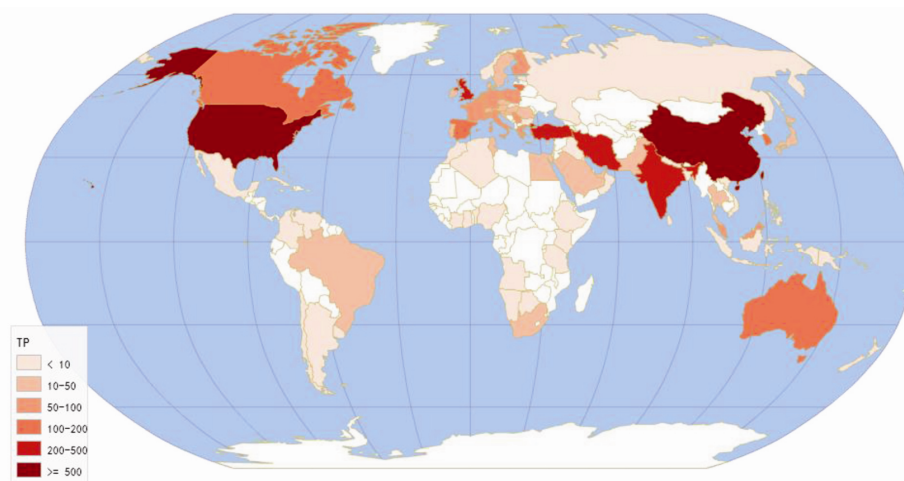


Figure 3. Distribution of global countries/territories of MCDM publications.

Table 1. Top 10 productive countries/territories in four different periods

Rank	Country/ territories	TP	TC	TC/TP	1977–1996		1997–2006		2007–2011		2012–2016	
					TP	TC	TP	TC	TP	TC	TP	TC
1	China	962	18,806	19.55	1	15	62	2730	180	7827	719	8234
2	Taiwan	530	14,867	28.05	10	536	81	4904	201	7349	238	2078
3	USA	527	11,194	21.24	67	1383	141	4615	112	3114	207	2082
4	Iran	461	6222	13.50	0	0	16	417	134	2994	310	2811
5	Turkey	403	8433	20.93	0	0	40	1816	127	4628	236	1989
6	India	266	5367	20.18	6	155	26	1703	68	1972	166	1537
7	UK	217	6107	28.14	12	610	53	2711	53	1670	99	1116
8	Spain	173	3926	22.69	6	156	29	1918	33	916	105	936
9	Lithuania	163	3296	20.22	0	0	1	84	26	1336	136	1876
10	Canada	139	2512	18.07	9	188	28	842	38	996	64	486

TP, Total number of publications; TC, Total number of citations.

the current dataset. Most of these 30 publications came out during the periods 1997–2006 and 2007–2011. Among these 30 papers, 7 publications were cited more than 500 times. According to the titles of these 30 publications, it is found that the MCDM methods involved include TOPSIS<sup>38,41–43</sup>, AHP (analytic hierarchy process)<sup>40,44</sup>, VIKOR<sup>38</sup>, and ANP (analytic network process)<sup>45</sup>. The research environment in which MCDM is applied mainly includes intuitionistic fuzzy and linguistic fuzzy environments. In addition, there are six reviews, of which two reviews are concerned with sustainable energy<sup>46,47</sup>. Other reviews are about application of MCDM methods to supplier evaluation and selection<sup>48</sup>, application of the AHP methods<sup>40</sup>, development of MCDM theory<sup>49</sup>, and development of fuzzy MCDM<sup>50</sup>.

*What are the influential journals in the MCDM field?*

To determine which journals tend to publish papers related to MCDM and receive more citations, the 10 most

influential journals in MCDM are listed in Table 3 based on statistical analysis, ranked according to TP and TC respectively. It indicates that *Expert Systems with Applications (ESWA)* ranks at the top, in values of both TP and TC. The *European Journal of Operational Research* also has a high number of publications and citations. According to the ranking of ten journals based on TP and TC in Table 3, it is seen that there are seven journals with high number of both publications and citations. There are three journals – *Fuzzy Sets and Systems (FSS)*, *International Journal of Production Economics (IJPE)*, and *Omega-International Journal of Management Science* – which only have around 40 publications each related to MCDM, but have received large number of citations – especially *FSS* and *IJPE*. Moreover, the three journals that have a higher TP with much lower TC values, include *Journal of Intelligent Fuzzy Systems (JIFS)*, *International Journal of Advanced Manufacturing Technology*, and *International Journal of Information Technology Decision Making*. On comparing these 3 journals with the top 10 journals based on TC, we find that their impact factor (IF)

**Table 2.** Top 30 most cited publications ranked according to TC

Rank	Title	Authors	Year	TC	Citations per year
1	Compromise solution by MCDM methods: a comparative analysis of VIKOR and TOPSIS	Opricovic, S. and Tzeng, G. H.	2004	834	64.15
2	Linguistic decision analysis: steps for solving decision problems under linguistic information	Herrera, F. and Herrera-Viedma, E.	2000	729	42.88
3	Analytic hierarchy process: an overview of applications	Vaidya, O. S. and Kumar, S.	2006	718	65.27
4	Some geometric aggregation operators based on intuitionistic fuzzy sets	Xu, Z. S. and Yager, R. R.	2006	593	53.91
5	A fuzzy approach for supplier evaluation and selection in supply chain management	Chen, C. T., Lin, C. T. and Huang, S. F.	2006	541	49.18
6	Application of multi-criteria decision making to sustainable energy planning – a review	Pohekar, S. D. and Ramachandran, M.	2004	520	40.00
7	Multi-criteria decision making approaches for supplier evaluation and selection: a literature review	Ho, W., Xu, X. W. and Dey, P. K.	2010	508	72.57
8	Review on multi-criteria decision analysis aid in sustainable energy decision-making	Wang, J. J., Jing, Y. Y., Zhang, C. F. and Zhao, J. H.	2009	435	54.38
9	Global supplier development considering risk factors using fuzzy extended AHP-based approach	Chan, F. T. S. and Kumar, N.	2007	394	39.40
10	Evaluating intertwined effects in e-learning programs: a novel hybrid MCDM model based on factor analysis and DEMATEL	Tzeng, G. H., Chiang, C. H. and Li, C. W.	2007	330	33.00
11	An extension of TOPSIS for group decision making	Shih, H. S.; Shyur, H. J. and Lee, E. S.	2007	316	31.60
12	Multi-attribute decision making: a simulation comparison of select methods	Zanakis, S. H., Solomon, A. Wishart, N. and Dublsh, S.	1998	298	15.68
13	Multi-criteria decision-making methods based on intuitionistic fuzzy sets	Liu, H. W. and Wang, G. J.	2007	294	29.40
14	Fuzzy TOPSIS method based on alpha level sets with an application to bridge risk assessment	Wang, Y. M. and Elhag, T. M. S.	2006	288	26.18
15	An evidential reasoning approach for multiple-attribute decision-making with uncertainty	Yang, J. B. and Singh, M. G.	1994	280	12.17
16	Using analytic network process and goal programming for interdependent information system project selection	Lee, J. W. and Kim, S. H.	2000	274	16.12
17	Dynamic intuitionistic fuzzy multi-attribute decision making	Xu, Z. S. and Yager, R. R.	2008	258	28.67
18	A slacks-based measure of super-efficiency in data envelopment analysis	Tone, K.	2002	235	15.67
19	Goal programming for decision making: an overview of the current state-of-the-art	Tamiz, M., Jones, D. and Romero, C.	1998	230	12.11
20	Product-driven supply chain selection using integrated multi-criteria decision-making methodology	Wang, G., Huang, S. H. and Dismukes, J. P.	2004	227	17.46
21	Deriving priorities from fuzzy pairwise comparison judgements	Mikhailov, L.	2003	227	16.21
22	Hesitant fuzzy prioritized operators and their application to multiple attribute decision making	Wei, G. W.	2012	225	45.00
23	Supplier selection with multiple criteria in volume discount environments	Xia, W. J. and Wu, Z. M.	2007	225	22.50
24	Generalized aggregation operators for intuitionistic fuzzy sets	Zhao, H., Xu, Z. S., Ni, M. F. and Liu, S. S.	2010	222	31.71
25	Multiple criteria decision making, multiattribute utility theory: recent accomplishments and what lies ahead	Wallenius, J., Dyer, J. S., Fishburn, P. C. Steuer, R. E. Zionts, S. and Deb, K.	2008	222	24.67
26	Application of TOPSIS in evaluating initial training aircraft under a fuzzy environment	Wang, T. C. and Chang, T. H.	2007	213	21.30
27	Multiple criteria decision making (MCDM) methods in economics: an overview	Zavadskas, E. K. and Turskis, Z.	2011	209	34.83
28	A fuzzy approach to select the location of the distribution center	Chen, C. T.	2001	209	13.06
29	Fuzzy multiple criteria decision making: recent developments	Carlsson, C. and Fuller, R.	1996	208	9.90
30	Fuzzy multiple attribute decision making: a review and new preference elicitation techniques	Ribeiro, R. A.	1996	200	9.52

## GENERAL ARTICLES

**Table 3.** Top 10 most influential journals ranked according to TC and TP

Rank	Journals	TP	TC	TC/TP	IF (2016)	Journals	TP	TC	TC/TP	IF (2016)
1	<i>Expert Systems with Applications</i>	244	9947	40.70	3.928	<i>Expert Systems with Applications</i>	244	9947	40.70	3.928
2	<i>European Journal of Operational Research</i>	136	7423	54.58	3.297	<i>Journal of Intelligent Fuzzy Systems</i>	179	874	4.88	1.261
3	<i>Fuzzy Sets and Systems</i>	45	3686	81.91	2.718	<i>European Journal of Operational Research</i>	136	7423	54.58	3.297
4	<i>International Journal of Production Economics</i>	49	2924	59.67	3.493	<i>Applied Soft Computing</i>	96	2084	21.71	3.541
5	<i>Knowledge-Based Systems</i>	72	2620	36.39	4.529	<i>International Journal of Production Research</i>	93	2156	23.18	2.325
6	<i>Information Sciences</i>	75	2564	34.19	4.832	<i>International Journal of Advanced Manufacturing Technology</i>	77	1264	16.42	2.209
7	<i>International Journal of Production Research</i>	93	2156	23.18	2.325	<i>Information Sciences</i>	75	2564	34.19	4.832
8	<i>Applied Soft Computing</i>	96	2084	21.71	3.541	<i>Knowledge-Based Systems</i>	72	2620	36.39	4.529
9	<i>Omega-International Journal of Management Science</i>	35	2045	58.43	4.029	<i>Computers Industrial Engineering</i>	68	1652	24.29	2.623
10	<i>Computers Industrial Engineering</i>	68	1652	24.29	2.623	<i>International Journal of Information Technology and Decision Making</i>	56	762	13.61	1.664

**Table 4.** Top 15 most influential authors ranked according to TC

Rank	Author	Institution	TP	TC	TC/TP	<i>h</i> -index
1	Tzeng, G. H.	Kainan University, Taiwan	76	3897	51.28	33
2	Xu, Z. S.	Sichuan University, China	70	3209	45.84	28
3	Zavadskas, E. K.	Vilnius Gediminas Technical University, Lithuania	95	2539	26.73	28
4	Wei, G. W.	Sichuan Normal University, China	39	1936	49.64	21
5	Turskis, Z.	Vilnius Gediminas Technical University, Lithuania	36	1289	35.81	17
6	Yager, R. R.	Iona College, USA	11	1067	97.00	5
7	Buyukozkan, G.	Galatasaray University, Turkey	25	1063	42.52	15
8	Chen, X. H.	Central South University, China	41	976	23.80	16
9	Romero, C.	Polytechnic University of Madrid, Spain	27	951	35.22	15
10	Wang, Y. M.	Shandong University of Finance and Economics, China	20	917	45.85	13
11	Opricovic, S.	University of Belgrade Faculty of Civil Engineering, Serbia	2	867	433.50	2
12	Wang, J. Q.	Central South University, China	38	813	21.39	16
13	Liu, P. D.	Shandong University of Finance and Economics, China	40	777	19.42	16
14	Zhao, X. F.	Chongqing University of Arts and Sciences, China	26	712	27.38	14
15	Kahraman, C.	Istanbul Technical University, Turkey	22	685	31.14	14

values are much lower. Although *JIFS* has 179 publications, lower than *ESWA* alone, its value of TC/TP is distinctly lower than the other nine journals. This means that the publications related to MCDM published in *JIFS* tend to receive less citations compared to the other journals listed in Table 3.

### Who has contributed to MCDM research?

Table 4 lists the institution, TP, TC, TC/TP, and *h*-index of the top 15 influential authors in the MCDM field, ranked according to TC. Tzeng, who has the highest TC, is ranked first. Xu follows, with a TC value close to Tzeng's. Zavadskas, who is ranked third, has the highest number of publications related to MCDM. Based on the value of TC/TP, we notice that Opricovic is ranked eleventh by TC even though he has only two papers to his credit. This is because, as given in Table 2, one of his

papers<sup>38</sup> received the most citations. Thus, his impact is high even though he has only two articles in our dataset. Another author, Yager, who has a high value of TC/TP with 11 publications in our dataset, has made important contributions to fuzzy research. Moreover, his research has contributed to the development of fuzzy MCDM research. In addition, Table 4 shows that 8 authors among the 15 most influential authors were from China and Taiwan. In the last ten years China and Taiwan have made significant contributions to MCDM research based on the number of publications and citations.

### What are the changes in the authors' collaborative structures?

Figure 4a-d shows the co-authorship networks of four periods. During the first 20 years, there was little co-authorship among researchers in the MCDM field,

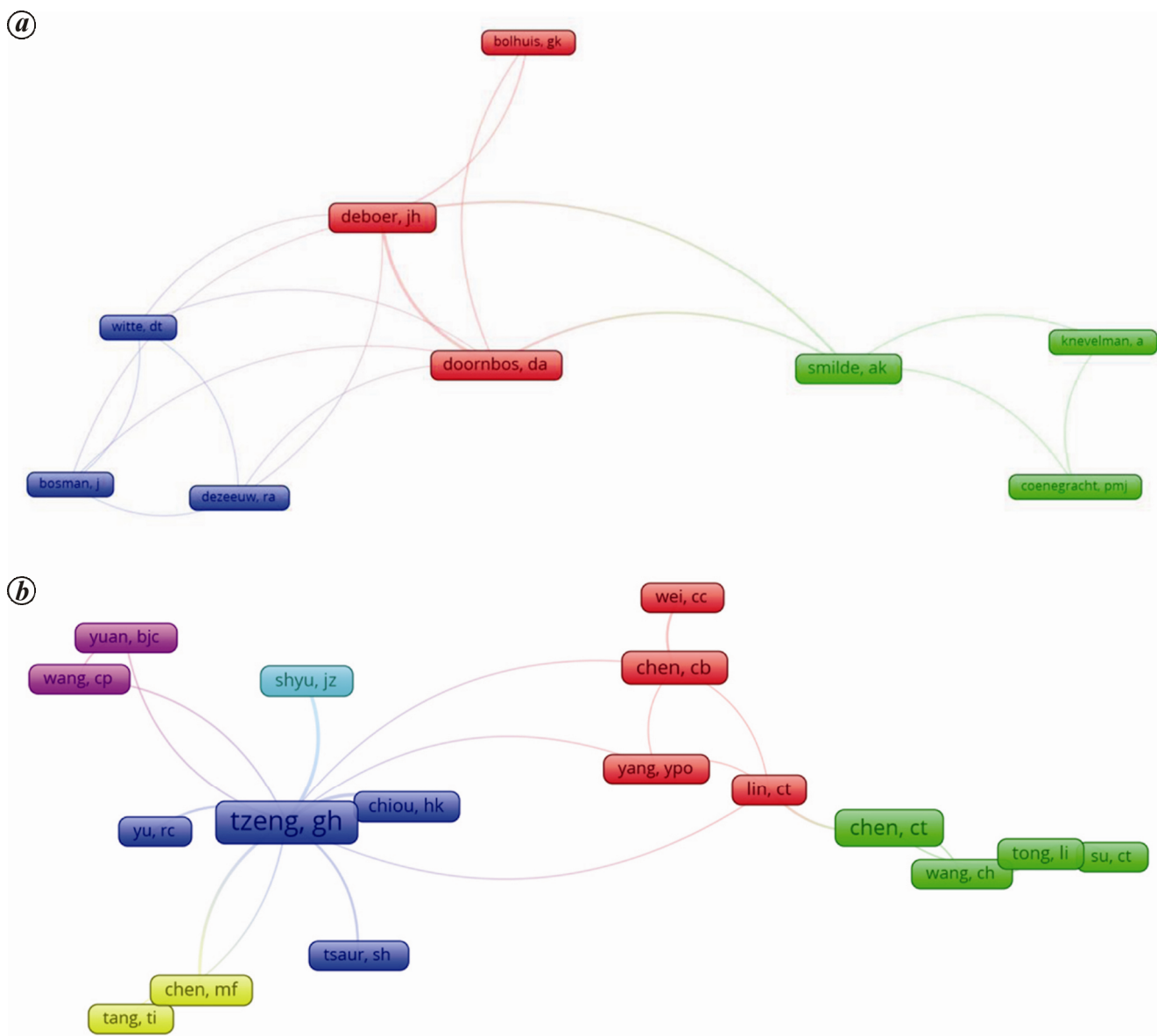
either in period of 1997–2006. In the last ten years, researchers in the MCDM field have cooperated with each other, especially during the period 2012–2016, when more number of researchers contributed to the MCDM field and had more collaboration.

As there is clearer co-authorship during the period 2012–2016 shown in Figure 4d, the detailed collaboration was analysed. Zavadskas E. K. had the most number of links with other researchers – strong cooperation was seen with Turskis Z., Antucheviciene J. (it is covered by the node of Zavadskas E. K.) and Hashemkhani Zolfani S., all of whom are from Vilnius Gediminas Technical University (Lithuania). Wang J. Q. had strong links with Chen X. H., Zhang H. Y. (it is covered by the node of Chen X. H.), and Wang, J., from Central South University

(China). Xu Z. S. had much more collaboration with Liao H.C. (it is covered by the node of Xu Z. S.) as both of them are from Sichuan University (China). Xu Z. S. also collaborated with Zhang X. L. and Xia M. M. as shown in the figure. Wei G. W. had strong collaboration with Zhao X. F., Lin R. (it is covered by the node of Wei G. W.), and Wang H. J., all of whom are from Chongqing University of Arts and Sciences (China) (Wei G.W. joined Sichuan Normal University, China in 2015).

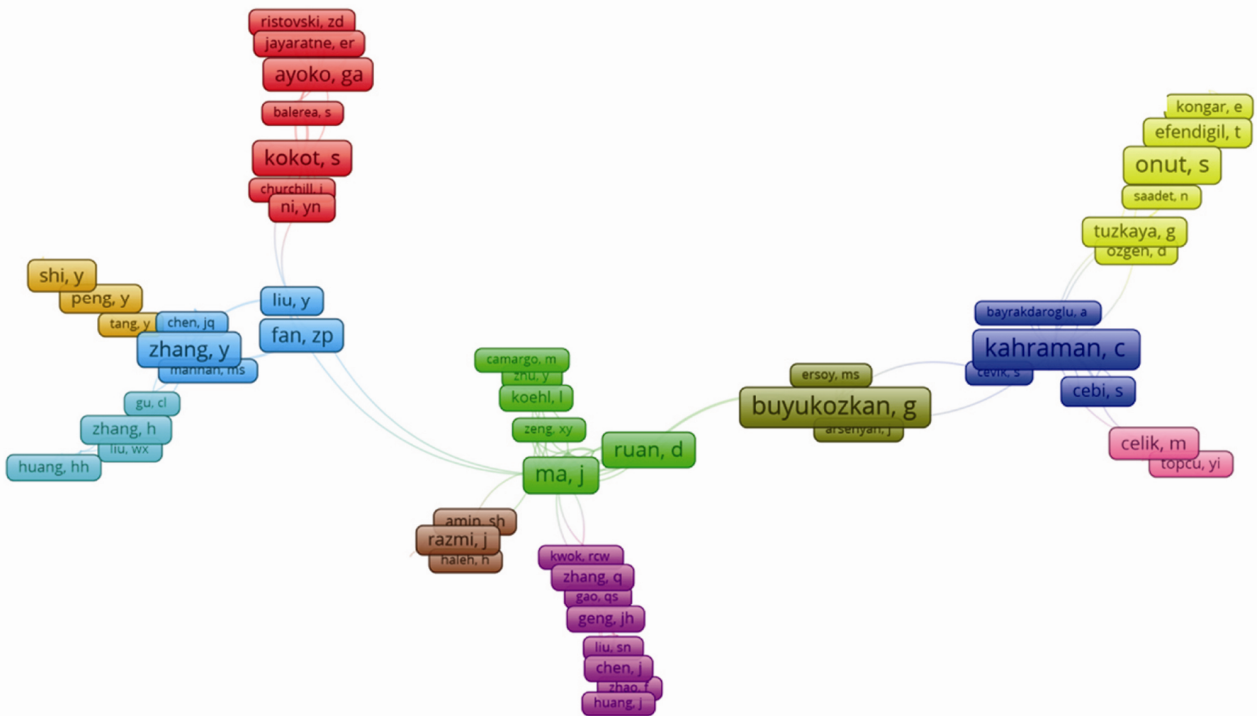
*What are the research focuses in different periods?*

Figure 5 a–d shows the co-word networks in four different periods. When these co-word networks were created, a



(Contd)

c



d

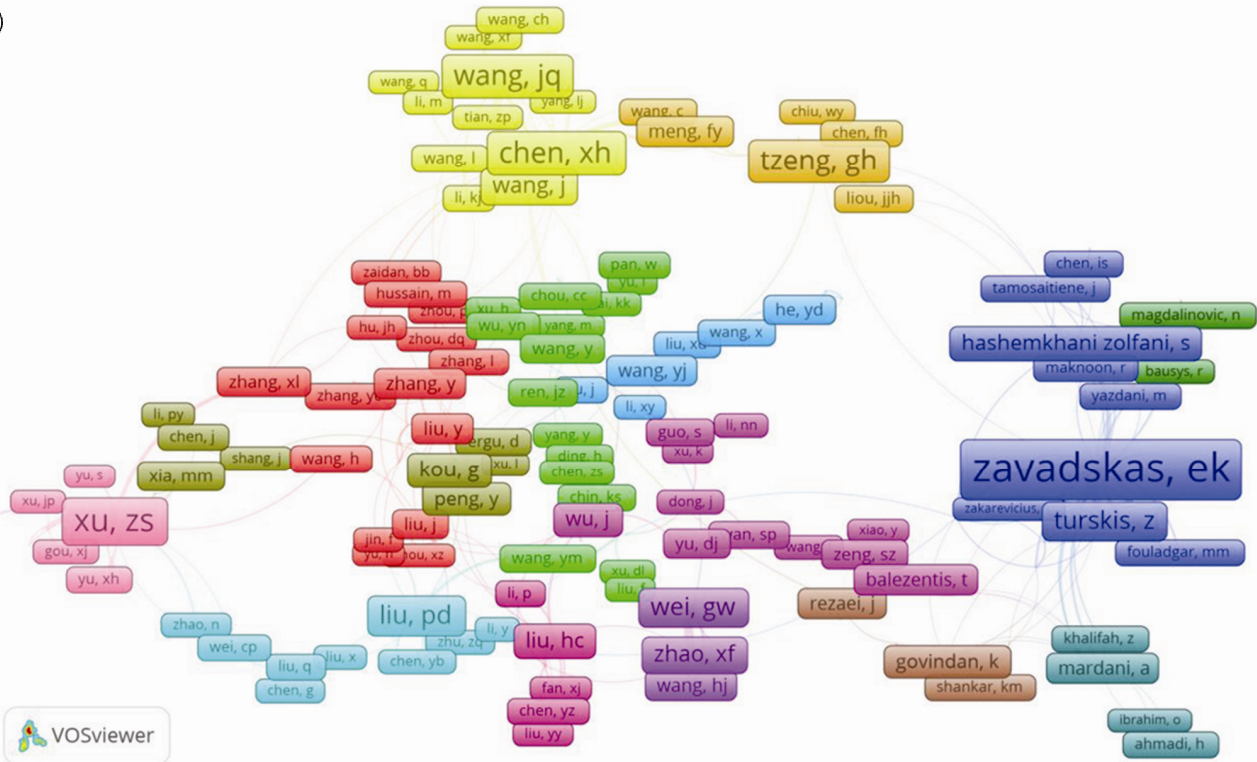
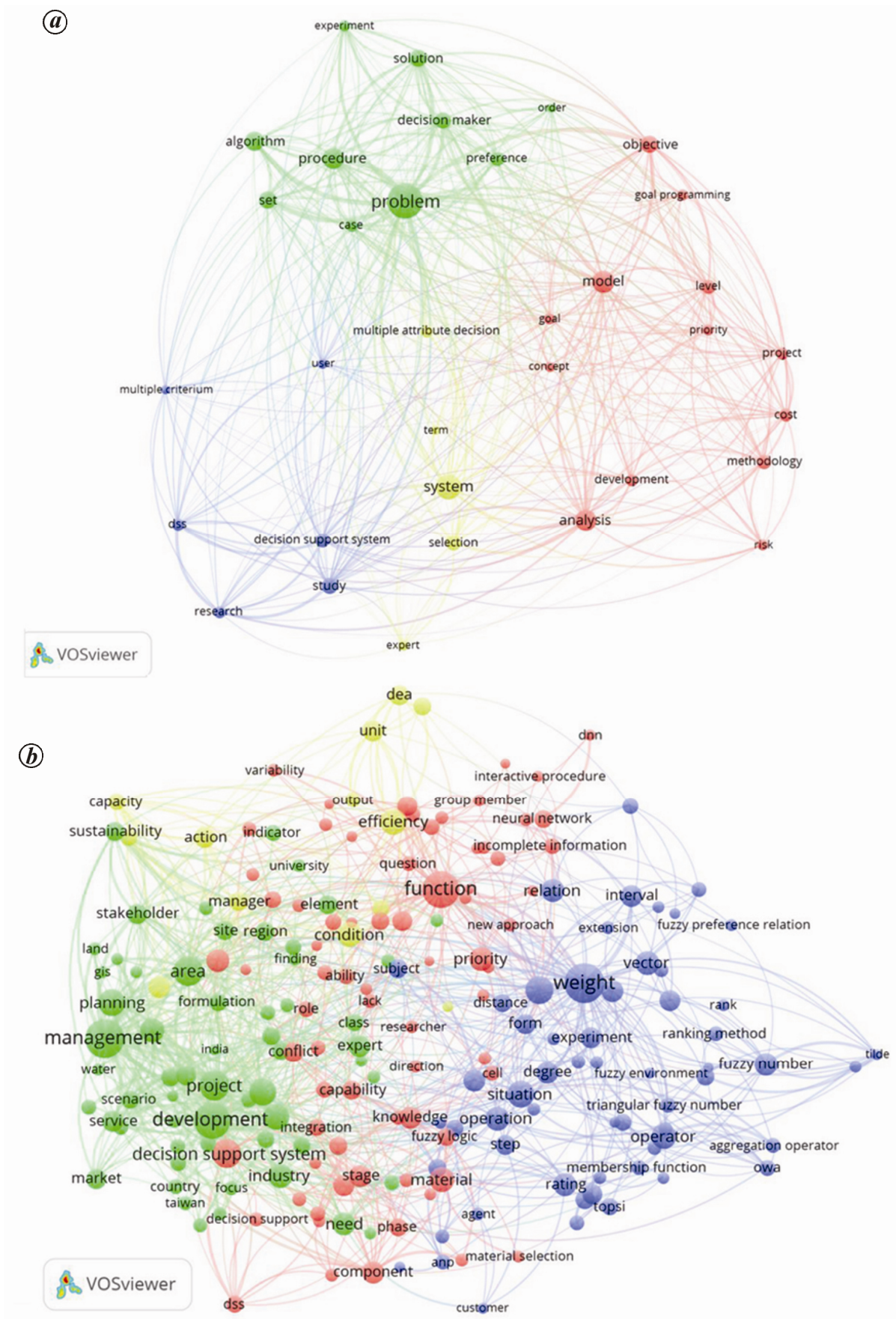


Figure 4. Co-authorship networks of four different periods: a, 1977–1996; b, 1997–2006; c, 2007–2011; d, 2012–2016.

threshold was set with the minimum number of occurrences of a term as ten. Those terms related to MCDM and MADM, such as ‘multi-criteria’, ‘multi-attribute’, ‘decision making’, are excluded from the terms, as they appear in almost every publication based on the search strategy of our dataset.

During the four decades, the terms related to MCDM research have clearly increased, and the focus of research also shows some changes. In the first decades, the focus of MCDM research was to develop the MCDM method and models to solve MCDM problems. In the 1997–2006 period, applications of MCDM, such as management,





(Contd)

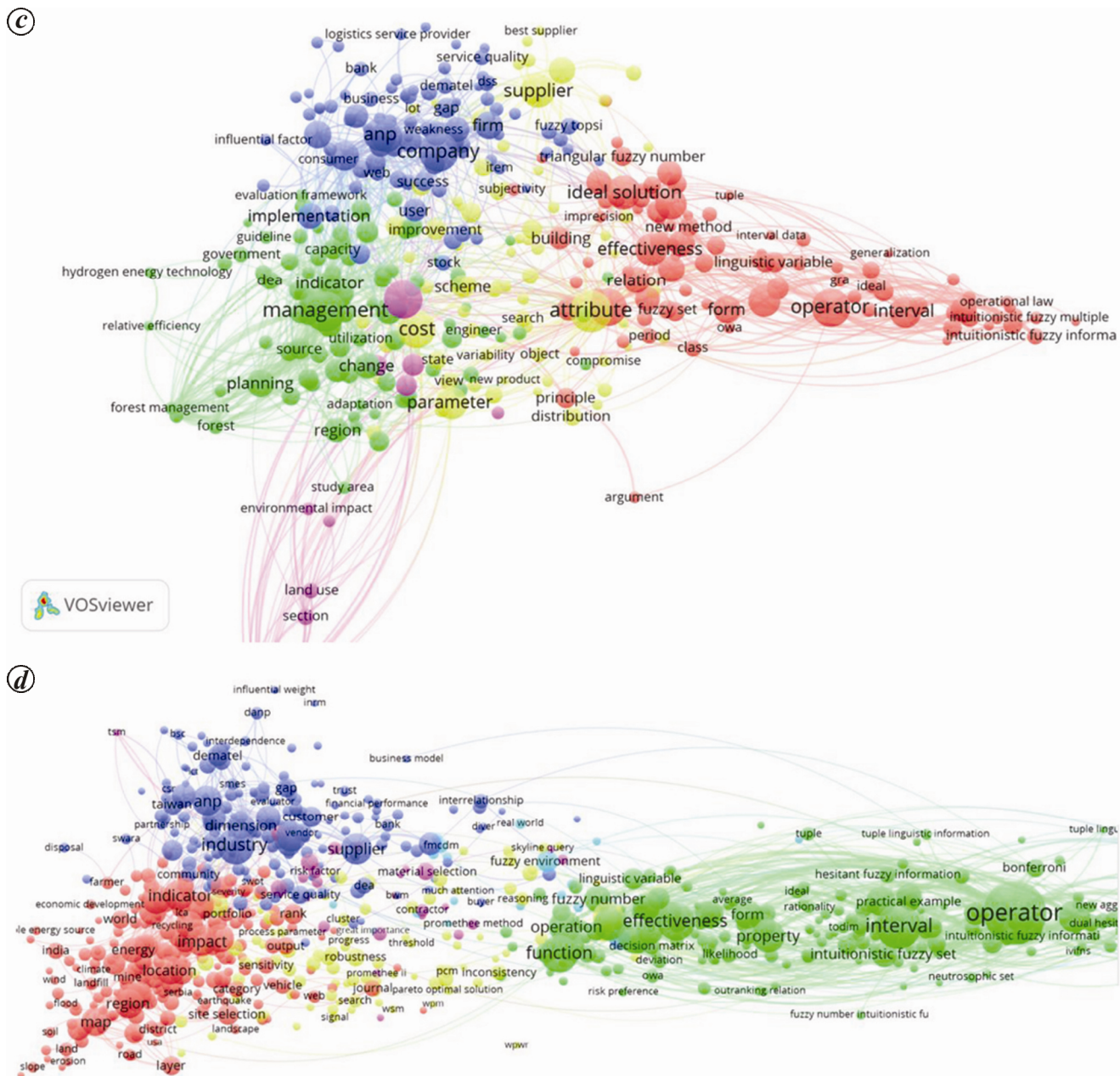


Figure 5. Co-word networks of four different periods: *a*, 1977–1996; *b*, 1997–2006; *c*, 2007–2011; *d*, 2012–2016.

planning and market were developed. Fuzzy numbers and operators were also combined with MCDM research. The research focus during this period is not clear, because there are many cross-links between terms from different clusters. In the last ten years, the strength of links between terms has increased. The research hotspot has become more concentrated with developments in related applications of MCDM methods, operators and fuzzy theories. On comparing the two periods of 2007–2011 and 2012–2016, it was observed that, the research focus of applying operators and interval-values fuzzy to MCDM increased during the latter five years. The research of applying MCDM methods to solve energy and

environment related problems also received more attention, especially in regions with abundant resources such as Iran and Turkey.

### Conclusion

In this paper, we analysed 4464 publications in the MCDM field from different angles by combining bibliometrics with social network methods. The publishing trend of publications, influential publications, countries/territories, journals, and the authors were analysed based on bibliometric analysis. Moreover, the dynamics

of collaboration among authors and research hotspots in the MCDM field were analysed by creating social networks during four different periods between 1977 and 2016. The number of publications in the MCDM field increased evidently since 2006, and the publications published between 2004 and 2014 obtained more citations on an average. In the last five years (2012–2016), publications from China, Taiwan, Iran, and Turkey have clearly increased, although USA was the leader in MCDM research at the beginning. Researchers from China, who have made great contributions to MCDM research, especially in the last five years, tend to cooperate with each other. Moreover, with the development of fuzzy theory, fuzzy MCDM research has attracted more attention in the last decade. Applications of MCDM to solve energy- and environment-related problems have also received attention especially in Iran and Turkey, which have abundant natural resources.

There is no denying that our research has limitations. First, our dataset only includes articles and reviews in the ISI WoS. However, there are many articles related to MCDM that are published in other journals that are not part of the ISI WoS retrieval system. Second, certain terms displayed on co-word networks have the same meaning, but are shown as similar words. In future, we plan to complete our dataset from other databases, pre-process the terms using text mining methods, and conduct studies from other angles to obtain a more accurate ranking of authors and journals. We also hope that our study will help other researchers in the MCDM field and other related disciplines.

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