

MULTI-CRITERIA DECISION-MAKING METHODS (MCDM): A BIBLIOMETRIC ANALYSIS (1974-2024)

DOI: 10.17261/Pressacademia.2024.1940

JBEF- V.13-ISS.2-2024(1)-p.55-67

Neylan Kaya

Akdeniz University, Business and Administration, Antalya, Turkiye.

neylankaya@akdeniz.edu.tr, ORCID: 0000-0003-2645-3246

Date Received: July 12, 2024

Date Accepted: October 29, 2024

**To cite this document**

Kaya, N., (2024). Multi-Criteria Decision Making Methods (MCDM): a bibliometric analysis (1974-2024). Journal of Business, Economics and Finance (JBEF), 13(2), 55-67.

Permanent link to this document: <http://doi.org/10.17261/Pressacademia.2024.1940>

Copyright: Published by PressAcademia and limited licensed re-use rights only.

ABSTRACT

Purpose- Multi-criteria decision-making (MCDM) is considered a complex decision-making (DM) tool that integrates both quantitative and qualitative factors. In recent years, various MCDM techniques and approaches have been proposed to select the best possible alternative. The overall aim of this study was to identify the tendencies and trends of the discipline over the past 50 years by conducting a bibliometric analysis of 10,387 studies published between 1974 and 2024 in the realm of multi-criteria decision-making methods (MCDM).

Methodology- In this regard, the Web of Science Core Collection database was utilized to retrieve articles related to "Multiple criteria decision-making", from which bibliometric data were extracted and analyzed. These studies were analyzed within the context of the number of publications by year, types of publications, language of publications, citation analysis, cooperation among countries, common citation networks and concept-topic orientations

Findings- The analysis unveiled a rapid increase in the number of publications after 2012, with studies predominantly taking the form of articles and being published in English. Besides, engineering emerged as the field with the highest number of publications, with the Analytical Hierarchy Process (AHP) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) being the most frequently used concepts. Zavadskas was identified as the author with the most publications and most cited on the subject. The journal with the highest number of citations was European Journal of Operational Research. Furthermore, the USA and China play a pivotal role in cooperation between countries.

Conclusion- This study is expected to make a valuable contribution to the relevant field as a determinant of some of the most effective researches, including influential journals, articles and authors in MCDM. Moreover, it may serve as a guide for researchers in terms of documenting the common tendencies in the field of MCDM

Keywords: Decision, decision making, multi-criteria decision making, bibliometric analysis, network analysis**JEL Codes:** C00, C02, C60**1. INTRODUCTION**

Individuals often make decisions –whether consciously or unconsciously- that can be classified as right or wrong in daily life. Decision-making is the process by which individuals, managers, institutions or decision-makers select one option from several alternatives (Işığçık, 2015). Real-world decision-making problems are typically complicated, and structures that focus solely on analyzing a single criterion or perspective may prove inadequate (Zavadskas & Turskis, 2011). The variety of criteria considered during decision-making and the complexity of the problems in real life make the process of decision-making challenging, leading to the emergence of multi-criteria decision-making. MCDM involves selecting the most suitable alternative from a set of options based on multiple criteria (Gürsakal, 2015). Ren, Xu and Gou (2016) noted that multi-criteria decision making method (MCDM) is the process of identifying the most appropriate alternative that behaves best in a limited set of alternatives with multiple criteria. The problem in MCDM lies in choosing a subset of alternatives that best aligns with both internal and external (Brans & Mareschal, 1992). Prioritizing criteria plays a crucial role in MCDM, as it helps in identifying the most suitable option (Yager, 2004). In his study, Yager (2004) prioritized and patterned MCDM problems through using the Bellman and Zadeh paradigm along with The Ordered Weighted Averaging (OWA) operator.

The number of publications on MCDM techniques has increased after 2000. Nevertheless, there has been a proliferation of diverse MCDM methods, the tendency to combine different MCDM techniques and the integration of them with the uncertainties encountered in daily problems (Marttunen, Lienart & Belton, 2017).

Judicial statements are usually subjective and ambiguous. Zadeh (1965) introduced the fuzzy set theory to address these challenges, aiming to quantify the ambiguity and subjectivity inherent in human judgments and to articulate linguistic terms

within the decision-making process. Belman and Zadeh (1970) were among the pioneering researchers to apply the fuzzy theory to decision-making problems. This approach offers decision-makers a systematic, consistent and efficient way to solve complex decision problems (Chen & Klein, 1997). The greatest strength of MCDM lies in its capacity to solve intricate problems. Today, widely used classical models are inadequate (Zavadskas & Turskis, 2011). Contemporary MCDM techniques focus on not only choosing among options but also discovering options, enhancing the learning process and fostering the discovery of common solutions (Belton & Stewart, 2002).

Today, MCDM is paramount in medical diagnosis, obtaining information, financial decision-making, pattern recognition and its use in new technologies (Yager, 2018; Predrycz, Ekel & Parreiras, 2010). In the future, MCDM methods will turn towards the areas of analysis of different scaling methods, analysis of preference relations, analysis of aggregation procedures, the study of grey relations, the study of fuzzy relations, the development and modification of new mathematical models to solve outranking problems (Zavadskas & Turskis, 2011). Recently, MCDM has been used to solve field problems such as energy (Dong, Li & Huang, 2018; Lee & Chang, 2018), environment and sustainability (An et. al., 2018; Cereska et. al., 2016), supply chain management (Yazdani, Zolfani & Zavadskas, 2016; Yu & Hou, 2016), material (Kiani, Liang & Gross, 2018; Giorgettia et. al., 2017), quality management (Sofiyabadi, Kolahi & Valmohammadi, 2016; Lupo, 2016), construction and project management (Wanga et. al., 2017; Jalilibala, Bozorgi-Amirib & Khosravi., 2018), security and risk management (Ishola, 2017; Gao, Liang & Xuan, 2016), production systems (Ranjan et al., 2016; Prakash & Barua, 2016) technology and information management (Lee et al., 2017; Chen et al., 2018), strategic management (Duan et al., 2017; Singh et. al., 2016), production management (Ranjan, Chatterjee & Chakraborty 2016; Prakash & Barua, 2016) and tourism management (Bagheri, Shojaei & Khorami 2018; Xiong et. al., 2017).

Bibliometrics is a quantitative method which employs statistical analysis to examine bibliographical information (Skinner, 2015; Borgman & Furner, 2002; Moed, 2005; Diodata, 2012). This approach provides an overall picture of a research field, categorizing it based on articles, authors and journals (Merigó & Yang, 2017). The earliest bibliometric study, known as "Zipf Law", was conducted by Zipf in 1934, focusing on words within quantitative practice researches (Jackson, 2012; Cowton, 1998). In 1936, Bradford conducted a mapping by using the subject sections of bibliographies to investigate the history of the subject named "Bradford Law" (Jackson, 2012; De Bellis, 2009). Another study in 2001 by Losee involved analyzing the frequency of literary reviews through a bibliography, calculating word counts for 400 selected documents that employed both Bradford Law and Zipf Law (Jackson, 2012; Bakulina, 2008).

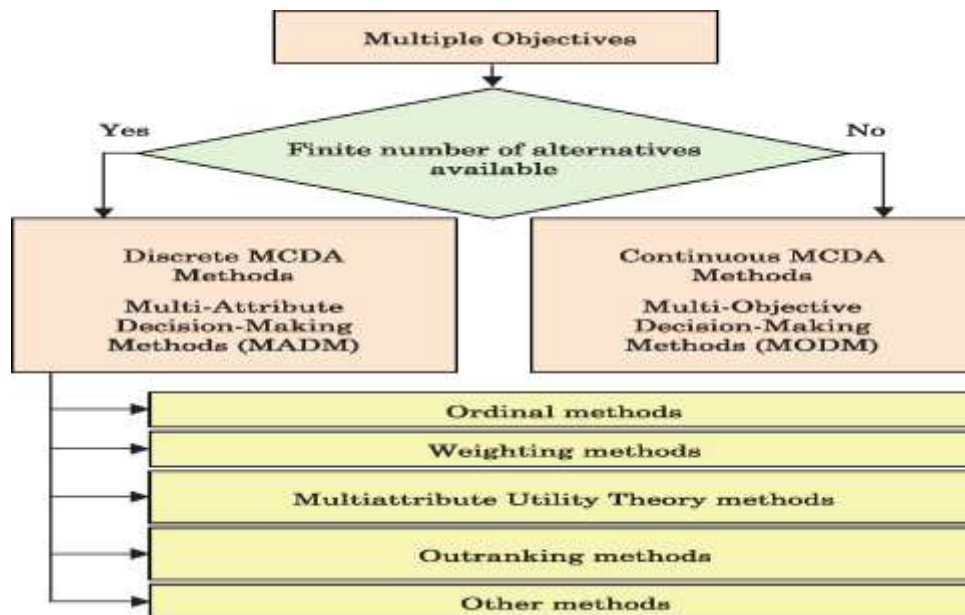
Traditional bibliometric analysis is based on ranking elements that analyze characteristics such as author characteristics, research methodology, and citations. Two commonly employed approaches are citation analysis and keyword analysis. Citation analysis indicates the primary contributors to a field, while keyword analysis highlights the predominant conceptual areas in a research domain (Diodato, 2012). Bibliometric research hold significant importance as they serve to gauge the current state of the subject under investigation, assess existing knowledge and comprehension, evaluate research quality, and inform future studies in the field. Thus, this study analyzed bibliometric studies conducted in the field of MCDM, as indexed in WOS.

2. CLASSIFICATION OF MCDM METHODS

As methods used to support decision-makers in problem solving evolve dynamically, precise classification poses challenges (Zavadskas & Turskis, 2011). Thus, different classification criteria are used by various researchers. One commonly cited classification divides MCDM methods into three groups (Francik et al., 2017); Methods of Multi-Attribute Utility Theory (MAUT), Methods of outranking and Interactive methods or multi-objective mathematical programming models. Francik et al. (2017) propose an alternative classification of MCDM (Figure 1).

Trzaskalik (2014a) and Trzaskalik (2014b) divided the discrete multi-criteria decision-making methods into 7 groups such as additive methods, the AHP method and related methods, verbal methods, Electre methods, Promethee methods, use of reference points, and interactive methods (Francik et. al. 2017; Trzaskalik, 2014a; Trzaskalik, 2014b).

Figure 1: Classification of Multicriteria Decision-Making Methods



Source: Kodikara, 2008; Piwowski, 2009; Kodikara, Sobczyk et. al., 2011; Francik et. al., 2017

3. BIBLIOMETRIC STUDIES IN THE FIELD OF MCDM

Recently, numerous studies have been specifically published on giving information regarding the development of MCDM methods and their applications across various domains (Mardani, Jusoh, & Zavadskas, 2015). This study attempts to present a bibliometric analysis using WOS database to elucidate the incrementally growing interest in MCDM techniques and approaches. In this section, the relevant literature on MCDM is displayed.

Chen et al. (2019), analyzed 1485 publications on the Analytic Network Process (ANP) indexed in WOS between 1996-2018. The research results revealed that 'Expert Systems with Applications' emerged as the most frequently cited journal with 118 articles. Besides, Sarkis's work (2003) titled "A strategic decision framework in green supply chain management" was identified as the most referenced publication. The keyword analysis depicted that ANP prominently appeared in keywords predominantly between 2011 and 2016, followed by MCDM, the Decision-making Trial and Evaluation Laboratory (DEMATEL), Fuzzy ANP, AHP, supplier selection, balanced scorecard, quality function spread, Geographic Information System (GIS), and combinations of ANP with various MCDM techniques. Taiwan led in the number of publications on ANP, with 436 articles, and Tzeng emerged as the researcher with the highest number of publications on ANP, totaling 56 articles.

Yu, Xu and Wang (2018) conducted a bibliometric analysis on the fuzzy theory research carried out in China over the past three decades. The study analyzed 12,936 studies on fuzzy theory conducted by Chinese researchers during this period, examining the geographic distribution of the studies, international cooperation, subject categories, journals of publication, and their contribution to the publications. Most studies were conducted in the Beijing region with American cooperation. Zadeh's (1965) study was prominent in terms of keywords such as total operator, system, algorithm, uncertainty, numerical examples, model, optimization, and linear matrix inequality. Engineering emerged as the dominant subject category. Most studies in this area were published in the journal "Fuzzy Sets and Systems".

Zyoud and Fuchs-Hanusch (2017) conducted a bibliometric analysis of 10,188 studies on AHP and 2412 studies on TOPSIS. The aim was to identify trends and conditions in research on these methods. The majority of studies on the AHP and TOPSIS were conducted in the field of engineering in China in 2016. The journal "Expert Systems with Application" emerged as the primary publication venue for studies on AHP and TOPSIS methods. The first study on AHP was published by Saaty (1977), while the first study on TOPSIS was authored by McCahon, Hwang and Tillman (1983) and appeared in Scopus. The University of Tehran hosted the most studies on AHP, while Islamic Azad University led in studies on TOPSIS.

Adunlin, Diaby and Xiao (2014) conducted a systematic bibliometric analysis on the use of MCDM in healthcare services. The research on the subject was carried out through scanning electronic databases, conference attendances and journals. The scope of the study consisted of 205 publications published in English between 1980 and 2013. An uptick in studies on the subject was noted in the years 1990, 1997, 1999, 2005, 2008 and 2012. Most studies regarding the subject were published on diagnosis and treatment in the journal of "Medical Decision Making" in the USA in 2012.

4. DATA AND METHODOLOGY

The study aims to identify the bibliometric characteristics of the studies in the domain of MCDM retrieved from the WOS database. The dataset consisted of 12,908 studies published in the field of MCDM between 1974 and 2024, as indexed in WOS. The search query employed the title "Multicriteria decision-making" within the WOS platform, yielding bibliometric data pertinent to the research objectives.

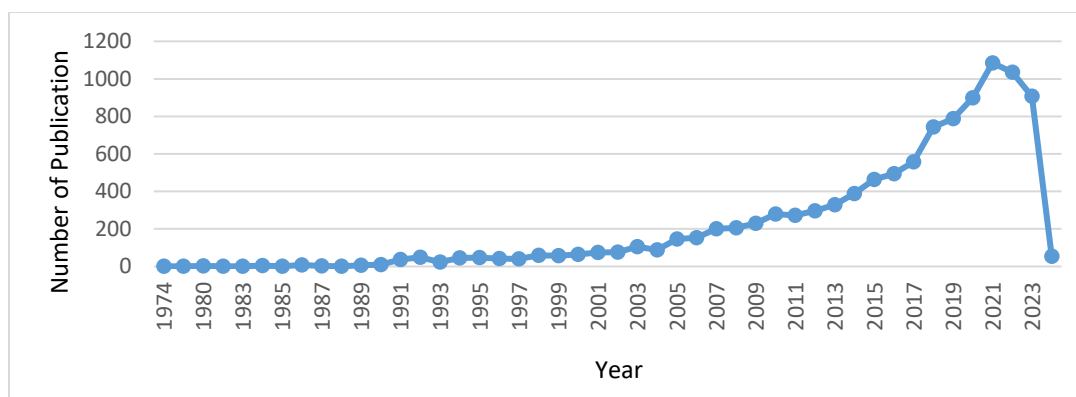
The studies published in the field of MCDM were analyzed based on various parameters, including the years of publication, research areas, types of studies, author names, language employed, authors' countries of origin, international cooperation, citations received from sources indexed in WOS, cited authors and keywords. The Vosviewer software was deployed to identify the collaborations among countries in the field of MCDM, common citation networks and concept-subject trends within the field.

5. FINDINGS AND DISCUSSIONS

5.1. Number of Publications by Year

The bibliometric analysis results suggested a notable trend towards the field starting in 2000. Figure 2 depicts the numbers of publications by year in the field of MCDM. The Pearson correlation coefficient between the years and the number of publications was found to be 0.78 ($p < 0.05$), indicating a statistically significant relationship with a high correlation between the years and the number of publications.

Figure 2: Number of publications in the field of MCDM between 1974-2024



The distribution of 10,387 studies published in the field of MCDM between 1974 and 2024 by year reveals the greatest number of studies occurred in 2021 ($n=1085$). It's worth noting that the decrease in the number of publications in 2024 may be attributed to the fact that the year has not yet concluded. The studies conducted within the last decade constituted 53.05 % of the total number of publications. This shows a notable rise in the number of studies, particularly in the last decade (Table 1).

Table 1: Distribution of Publications by Years

Year	Number of papers	Percentage (%)
1974-1984	15	0,14
1985-1995	233	2,24
1996-2006	911	8,77
2007-2017	3717	35,78
2018-2024	5511	53,05

5.2. Publication Types

Table 2 displays the distribution of publication types in the field of MCDM.

Table 2: Distribution of Publication by Types

Publication type	Number of papers	Percentage (%)
Article	8643	78,50
Proceeding Paper	1541	13,99
Review Article	404	3,66

Book Chapters	185	1,68
Others	237	2,15

The studies in the field were categorized into 16 types, with some publications falling under multiple types. Some studies were written in different document types. Upon analyzing 11010 studies, they were found to be mostly articles and proceedings, and they numbered 10184 in total (92.49%).

5.3. Publication Languages

The analysis findings showed that studies were written in 18 different languages. The overwhelming majority, comprising 10,176 publications (97.95%) out of 10,387, were written in English. This was followed by 55 publications in Spanish, 43 in Portuguese, 25 in Turkish and 20 in Russian. Table 3 displays the distribution of the publications by language.

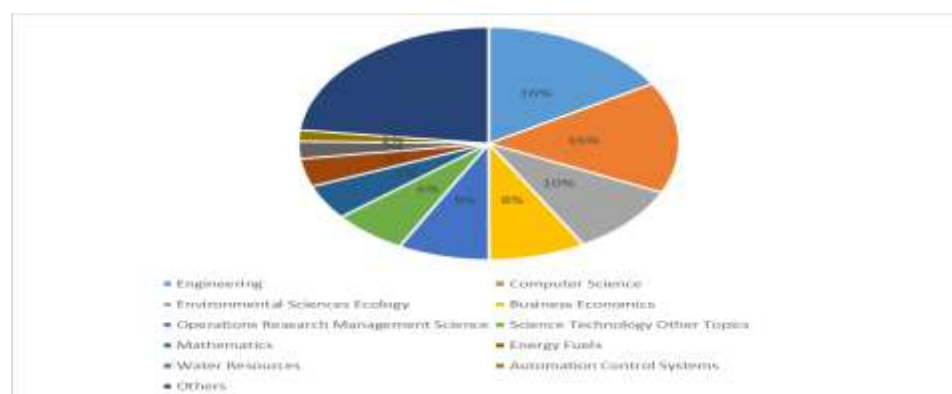
Table 3: Distribution by Publication Language

Language	Number of papers	Percentage (%)
English	10176	97,95
Spanish	55	0,52
Portuguese	43	0,41
Turkish	25	0,24
Russian	20	0,19
Others	68	0,66

5.4. Publication Trends by Research Area

Figure 3 illustrates the areas predominantly researched in studies on MCDM.

Figure 3: The 10 Mostly Studied Research Areas Regarding MCDM between 1974-2024



The top 10 researched areas regarding MCDM were respectively engineering, computer science, environmental sciences ecology, business economics, operations research management science, science technology other topics, mathematics, energy fuels, water resources and automation control systems. Some studies took place in different application field. The contribution of the research areas to MDCM are presented in Table 4.

Table 4: Contribution of the Research Areas

Application field	Number of papers	Percentage (%)
Engineering	2974	16,42
Computer Science	2805	15,49
Environmental Sciences Ecology	1781	9,83
Business Economics	1490	8,22
Operations Research Management Science	1408	7,77
Science Technology Other Topics	1152	6,36
Mathematics	880	4,86
Energy Fuels	710	3,92
Water Resources	433	2,39
Automation Control Systems	282	1,55
Others	4191	23,14

Engineering, the most researched area, constituted 16.42% of the studies conducted in the last 50 years.

5.4. Top Ten Lists of Corresponding Authors, their Countries of Residence and the Journal

The bibliographic analysis showed that Zavadskas conducted the greatest number of studies as a corresponding author. The total number of publications between 1974 and 2024 by the top ten corresponding authors, who had the highest number of publications on MCDM, accounted for 0.05% of the total number of publications on the subject. Authors with the highest number of publications related to the field as corresponding authors are depicted in Figure 4.

Figure 4: Top 10 Authors Studying Mostly in the Field of MCDM between 1974 and 2024

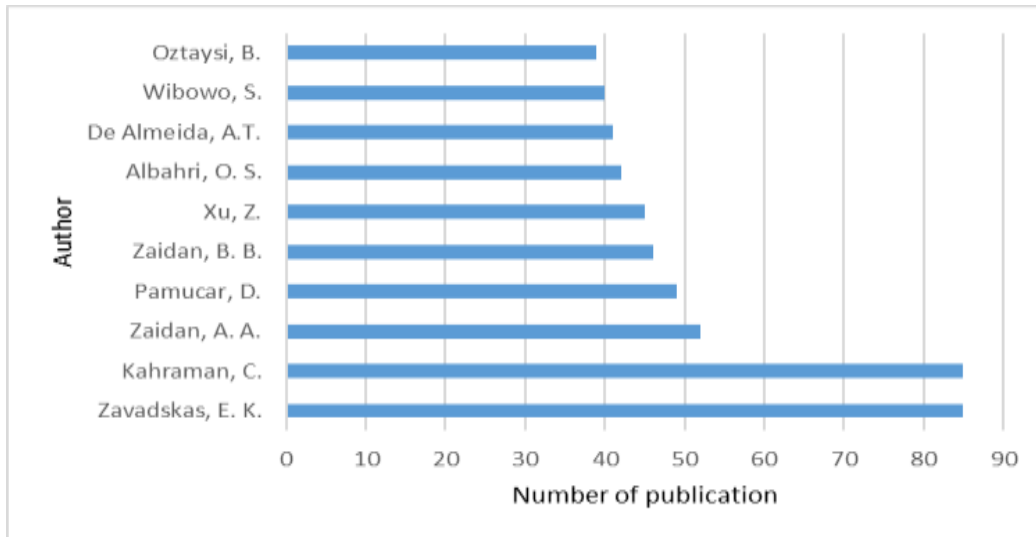


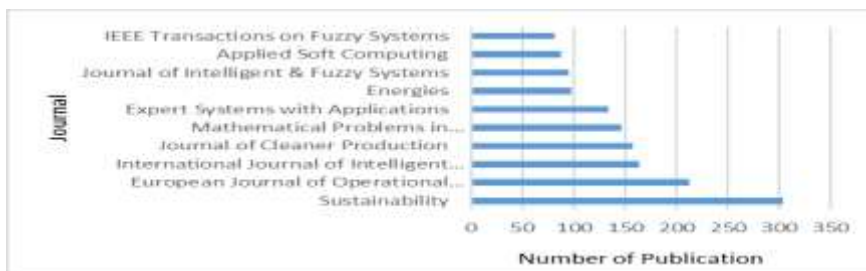
Table 5 summarizes the top 10 authors who have extensively contributed to the field as corresponding authors, along with their countries, number of publications, percentages, total number of publications citing these authors, and average citation numbers.

Table 5: Top 10 Authors by Number of Publications

Authors	Number of papers	Total number of citing publications
Zavadskas, E. K.	85	6985
Kahraman, C.	85	4667
Zaidan, A. A.	52	2147
Pamucar, D.	49	1807
Zaidan, B. B.	46	2123
Xu, Z.	45	3950
Albahri, O. S.	42	1595
De Almeida, A.T.	41	910
Wibowo, S.	40	255
Oztaysi, B.	39	1715

Upon analyzing the total number of publications citing the works of the top 10 authors, Zavadskas emerged as the leader in terms of total citations. Figure 5 depicts the journals publishing the highest number of studies on MCDM.

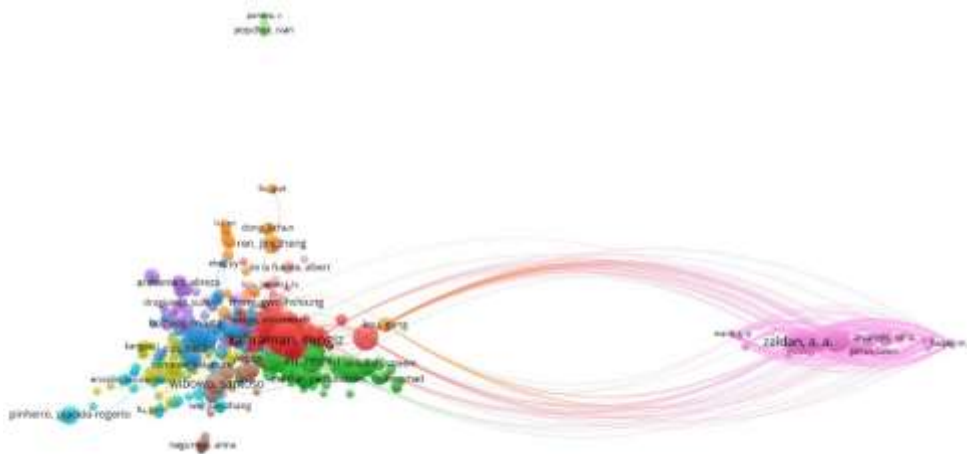
Figure 5: Top 10 Journals Publishing the Highest Number of Studies on MCDM between 1974-2024



International Journal of Intelligent Systems	164	8476	1181
Journal of Cleaner Production	158	6272	733
Renewable&Sustainable Energy Reviews	71	6195	981
Fuzzy Sets and Systems	79	5616	481
Journal of Environmental Management	79	4515	452
Omega-International Journal of Management Science	70	4370	614
Sustainability	304	4366	955

The journals were ranked in the following order based on the number of citations received by their publications: European Journal of Operational Research, Expert Systems with Applications, IEEE Transactions on Fuzzy Systems. When considering the journals' total link strength to the other journals, their ranking was as follows: European Journal of Operational Research, Expert Systems with Applications and International Journal of Intelligent Systems. These journals were identified together based on network density. Figure 8 presents the authors who were cited together in these journals.

Figure 8: Author Joint Citation Network Map



The size of the text font and the size of the circles denote authors who were cited more. Nine sets of authors were mainly formed, each exhibiting strong link among the authors within the set.

Table 9: Top 10 Authors Contributing to the Subject

Author	Number of Citation	Total Link Strength
Zavadskas, E. K.	6985	1746
Yager, R. R.	5776	407
Yager, R. R.	4951	918
Kahraman, C.	4667	1708
Xu, Z.	3950	764
Turskis, Z.	3720	957
Ye, J.	3037	326
Garg, H.	2951	504
Tzeng, G-H	2548	443
Herrera, F.	2324	127

In the 10387 studies published on MCDM, the most cited authors were determined to rank as Zavadskas (n=6985), Yager (n=10727), Kahraman (n= 4667), Xu (n=3950), Turskis (n=3720) and Ye (n=3037). These authors were cited together with the others (Table 9).

5.7. Popular MCDM Research Topics and Trends

A network analysis revealed frequent co-occurrences of keywords within the related literature. A total of 23,587 keywords were identified across 12,908 studies. Figure 9 shows the network analysis of the keywords in the publications on MCDM.

Figure 9: Keyword Network Map

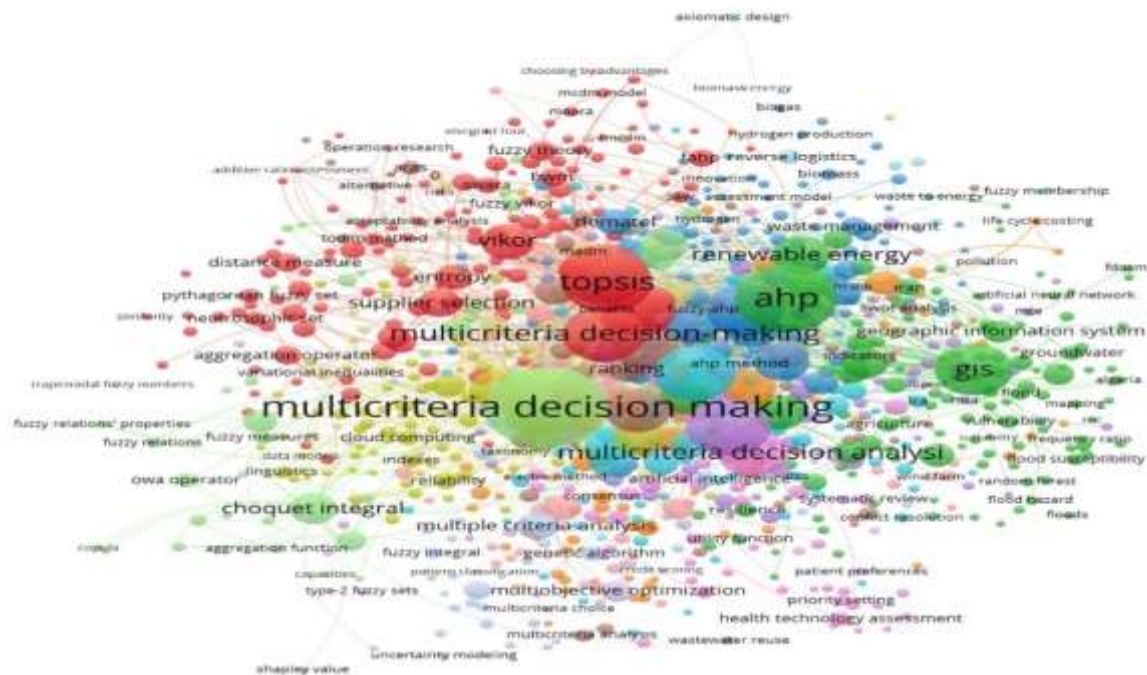


Table 10 shows the most popular methods, concepts and frequency of their use on MCDM.

Table 10: Popular Methods and Concepts

Method/Concept	Frequency	Total Link Strength
Ahp	1094	2523
Topsis	405	1075
Geographic Information System (GIS)	296	685
Sustainability	285	683
Uncertainty	171	511
Renewable Energy	166	434
Fuzzy Sets	161	490
Sustainable Development	152	415
Fuzzy Logic	152	358
Promethee	143	368

The most frequently used keyword was noted to be AHP (n=1094). This was followed by TOPSIS (n=405). AHP, TOPSIS, Geographic Information System (GIS), sustainability, uncertainty, renewable energy, fuzzy sets, sustainable development, fuzzy logic, Promethee were the prominent topics in the studies on MCDM.

AHP, the most frequently used term in MCDM, is often associated with methods such as the TOPSIS, Fuzzy AHP, Fuzzy TOPSIS, VIKOR, PROMETHEE and Dematel. Besides, it is commonly linked with concepts including supplier selection, sustainability, fuzzy logic, Geographic Information System (GIS), and site selection.

6. CONCLUSION AND IMPLICATIONS

In recent years, MCDM methods have been developing rapidly with various modelling techniques and approaches. This surge in development has coincided with a dramatic increase in publications within the field. Easy access to the developing information, coupled with challenges in interpretation, along with the proliferation of software tailored for MCDM, has fueled a rise in studies within this domain. This study aims to conduct a comprehensive bibliometric analysis of 10,387 studies published between 1974 and 2024 in the field of MCDM, shedding light on key trends and insights within the discipline. The

study is of great importance as it reveals the systematics of the field by reporting the trends and tendencies in the last 50 years by themes. The study includes the relevant articles available on the WOS database. This study employed text mining and visualization analysis to comprehensively analyze a substantial volume of data and categorize it for interpretation. A total of 10387 studies conducted between 1974 and 2024 were analyzed. The results showed that the interest in MCDM increased after 2000, with the greatest number of studies recorded in 2021 (n=1085). MCDM studies were mostly written in the form of articles, and in English. The studies searched in WOS spanned across 112 different fields. Most of these studies were in the fields of engineering (n=2974), computer science (n=2805), and environmental sciences ecology (n=1781). Complex decision-making problems in the field of engineering increased the application of MCDM methods in the field.

Another finding of the study suggested the prominent role of the USA in fostering cooperation among countries. Turkey took the 3rd place in both the number of publications and citations. Among journals, European Journal of Operational Research was determined as the most cited within citation network analysis. Zavadskas emerged as the most cited author. The study titled "Generalized Orthopair Fuzzy Sets" written by Yager in 2017 was identified as the most up-to-date study among the top 10 most cited sources.

It may be wise to mention that applied studies held a considerable position within the field. The results of the keyword network analysis revealed that MCDM was frequently associated with various methods, including Ahp, Topsis, Vikor, Fuzzy Topsis, Fuzzy Ahp, Promethee, Dematel, as well as concepts involving decision making, supplier selection, sustainability, renewable energy and GIS. This study is expected to make a valuable contribution to the relevant field as a determinant of some of the most effective researches, including influential journals, articles and authors in MCDM. Moreover, it may serve as a guide for researchers in terms of documenting the common tendencies in the field of MCDM.

REFERENCES

- Adunlin, G., Diaby, V., Xiao, H. (2014)..Application of multicriteria decision analysis in health care:a systematic review and bibliometric analysis. *Health Expectations*, 18(6), 1894-1995
- Bagheri, M., Shojaei, P., Khorami, M.T. (2018). A comparative survey of the condition of tourism infrastructure in Iranian provinces using VIKOR and TOPSIS, *Decision Science Letters*, 7(1), 87–102. <http://dx.doi.org/10.5267/j.dsl.2017.4.001>
- Bakulina, M. P. (2008). Application of the Zipf law to text compression, *Journal of Applied and Industrial Mathematics*, 2(4), 477-483.
- Bellman, R. E., Zadeh, L. A. (1970). Decision-making in a fuzzy environment, *Management Science*, 17(4), 141-164. <https://doi.org/10.1287/mnsc.17.4.B141>
- Belton, V., Stewart, T. J. (2002). *Multiple criteria decision analysis - An integrated approach*, Boston, Kluwer.
- Borgman, C. L., Furner, J. (2002). Scholarly communication and bibliometrics. *Annual Review of Information and Technology*, 36(1), 2-72. <https://asistdl.onlinelibrary.wiley.com/doi/epdf/10.1002/aris.1440360102>
- Chen, C. B., Klein, C. M. (1997). An efficient approach to solving fuzzy MADM problems, *Fuzzy Sets and Systems*, 88(1), 51-67. [https://doi.org/10.1016/S0165-0114\(96\)00048-6](https://doi.org/10.1016/S0165-0114(96)00048-6)
- Chen, C. T., Huang, S. F., Hung, W. Z. (2018). Linguistic VIKOR method for project evaluation of ambient intelligence product, *Journal of Ambient Intelligence and Humanized Computing*, 1-11. <https://doi.org/10.1007/s12652-018-0889-x>
- Chen, Y., Jin, Q., Fang, H., Lei, H., Hu, J., Wu, Y., Chen, J., Wang, C., Wan, Y. (2019). Analytic network process: Academic insights and perspectives analysis, *Journal of Cleaner Production*, 235, 1276-1294.
- Cowton, Christopher J. (1998). The use of secondary data in business ethics research, *Journal of Business Ethics*, 17 (4), 423-434. <https://doi.org/10.1023/A:1005730825103>
- De Bellis, N. (2009). *Bibliometrics and citation analysis*, Lanham, Scarecrow Press Inc.
- Diodato, V. (2012). *Dictionary of bibliometrics*, Routledge, Taylor & Francis Group, Newyork, The Haworth Press.
- Dong, J., Li, R., Huang, H. (2018). Performance Evaluation of Residential Demand Response Based on a Modified Fuzzy VIKOR and Scalable Computing Method, *Energies*, 11(5), 1097. <https://doi.org/10.3390/en11051097>
- Duan, R., Hu, L., Lin, Y. (2017). Fault diagnosis For complex systems based on dynamic evidential network and multi-attribute decision making with interval numbers, *Eksplotacja i Niezawodnosc – Maintenance and Reliability*, 19 (4), 580–589. <http://dx.doi.org/10.17531/>
- Francik, S., Pedryc, N., Knapczyk, A., Wojcik, A., Francik, R., Lapczynska-Kordon, B. (2017). Bibliometric analysis of multiple criteria decision making in agriculture, *Technical Sciences*, 20(1),17-30. <http://dx.doi.org/10.31648/ts.2906>
- Gao, Z., Liang, R., Xuan, T. (2016). VIKOR Method for Ranking Concrete Bridge Repair Projects with Target-Based Criteria, *Results in Engineering*, 3, 1-9. <https://doi.org/10.1016/j.rineng.2019.100018>
- Giorgetta, A., Cavallinib, C., Arcidiacono, G., Citti, P. (2017). A Mixed C-VIKOR Fuzzy Approach for Material Selection during Design Phase: A Case Study in Valve Seats for High Performance Engine, *International Journal of Applied Engineering Research*, 12(12), 3117-3129.

- Gürsakar, S. (2015). Karar Verme, Çok Kriterli Karar Verme Yöntemleri, 1. Baskı, (Ed: M. Aytaç ve N. Gürsakar), Dora Yayıncılık, 243-272, Bursa.
- Ishola, A. (2017). Advances safety methodology for risk management of petroleum refinery operations, Doctoral Thesis, Liverpool John Moores University, Doctor of Philosophy, UK.
- Işığışık, E. (2015). Karar Verme, Mustafa Aytaç (Ed) ve Necmi Gürsakar (Ed), Dora Yayıncılık, 1-32, Bursa.
- Jackson, M. (2012). A Bibliometric analysis of green building literature, Doctoral Dissertation, Faculty of the School of Business and Technology Management, Northcentral University, Prescott Valley, Arizona.
- Jalilibala, Z., Bozorgi-Amirib, A., Khosravi, R. (2018). A hybrid lexicographic and VIKOR approach for prioritizing construction projects by considering sustainable development criteria, Journal of Project Management, 3, 131–142. <http://dx.doi.org/10.5267/j.ipm.2018.3.001>
- Kiani, B., Liang, R. Y., Gross, J. (2018). Material selection for repair of structural concrete using VIKOR method, Case Studies in Construction Materials, 8, 489–497. <https://doi.org/10.1016/j.cscm.2018.03.008>
- Kodikara, P. N. (2008). Multi-Objective Optimal Operation of Urban Water Supply Systems, PhD Thesis, Victoria University, Australia.
- Lee, H. C., Chang, C. T. (2018). Comparative analysis of MCDM methods for ranking renewable energy sources in Taiwan, Renewable and Sustainable Energy Reviews, 92, 883-896. <https://doi.org/10.1016/j.rser.2018.05.007>
- Lee, A. H. I., Kang, H. Y., Liou, Y. J. (2017). A Hybrid Multiple-Criteria Decision-Making Approach for Photovoltaic Solar Plant Location Selection, Sustainability, 9(2), 1-21. <https://doi.org/10.3390/su9020184>
- Lupo, T. (2016). A Fuzzy Framework to evaluate service quality in the healthcare industry: An empirical case of public hospital service evaluation in Sicily, Applied Soft Computing, 40, 468-478. <https://doi.org/10.1016/j.asoc.2015.12.010>
- Mardani, A., Jusoh, A., Zavadskas, E. K. (2015). Fuzzy multiple criteria decision-making techniques and applications - Two decades review from 1994 to 2014, Expert Systems with Applications, 42, 4126-4148. <https://doi.org/10.1016/j.eswa.2015.01.003>
- Marttunen, M., Lienart, J., Belton, V. (2017). Structuring problems for Multi-Criteria Decision Analysis in Practice: A Literature Review of Method Combinations, European Journal of Operational Research, 263(1), 1-17. <https://doi.org/10.1016/j.ejor.2017.04.041>
- McCahon, C. S., Hwang, C. L., & Tillman, F. A. (1983). A multiple attribute evaluation of Bayesian availability estimators. IEEE transactions on reliability, 32(5), 496-503.
- Merigo, J. M., Yang, J. B. (2017). A bibliometric analysis of operations research and management science, Omega, 27(1), 71-100. <https://doi.org/10.1016/j.omega.2016.12.004>
- Moed, H. F. (2005). Citation Analysis in Research Evaluation, Dordrecht, Netherlands: Springer.
- Piowowski, M. (2009). Wielokryterialna analiza decyzyjna w systemach GIS, Polskie Stowarzyszenie Zarządzania Wiedzą, Seria: Studia i Materiały, 18, 123–134.
- Prakash, C., Barua, M.K. (2016). A Combined MCDM approach for evaluation and selection of third-party reverse logistics partner for Indian electronics industry, Sustainable Production and Consumption, 7, 66-78. <https://doi.org/10.1016/j.spc.2016.04.001>
- Predrycz, W., Ekel, P., Parreiras, R. (2010). Fuzzy multicriteria decision-making: Models, Methods and Applications, John Wiley, New York.
- Ranjan, R., Chatterjee, P., Chakraborty, S. (2016). Performance evaluation of Indian Railway zones using DEMATEL and VIKOR methods, Benchmarking an International Journal, 23(1), 78-95. <http://dx.doi.org/10.1108/BIJ-09-2014-0088>
- Ren, P., Xu, Z., Gou, X. (2016). Pythagorean fuzzy TODIM approach to multi-criteria decision making, Applied Soft Computing, 42, 246-259. <https://doi.org/10.1016/j.asoc.2015.12.020>
- Saaty, T. L. (1977). A Scaling Method for Priorities in Hierarchical Structures, Journal of Mathematical Psychology, 15(3), 234-281. [https://doi.org/10.1016/00222496\(77\)90033-5](https://doi.org/10.1016/00222496(77)90033-5)
- Sarkis, J. (2003). A strategic decision making framework for green supply chain management, Journal of Cleaner Production, 11(4), 397-409. [http://dx.doi.org/10.1016/S0959-6526\(02\)00062-8](http://dx.doi.org/10.1016/S0959-6526(02)00062-8)
- Skinner, J. K. (2015). Bibliometric and social network analysis of doctoral research: Research trends in distance learning, The University of New Mexico, Doctor of Philosophy, Organization Information and Learning Sciences, Albuquerque, New Mexico.
- Singh, S., Olugu, E.U., Musa, S.N., Mahat, A.B., Wong, K. Y. (2016). Strategy selection for sustainable manufacturing with integrated AHP-VIKOR method under interval-valued fuzzy environment, The International Journal of Advanced Manufacturing Technology, 84(1-4), 547-563. <https://doi.org/10.1007/s00170-015-7553-9>
- Sobczyk, E. J., Wota, A., Krezolek, S. (2011). Zastosowanie matematycznych metod wielokryterialnych do wyboru optymalnego wariantu źródła pozyskania węgla kamiennego, Gospodarka Surowcami Mineralnymi/Mineral Resources Management, 27, 51–68.

- Sofiyabadi, J., Kolahi, B., Valmohammadi, C. (2016). Key performance indicators measurement in service business: a fuzzy VIKOR approach, 27(9-10), 1028-1042. <https://doi.org/10.1080/14783363.2015.1059272>
- Trzaskalik, T. (2014a). Wielokryterialne wspomaganie decyzji, Metody i zastosowania, PWE, Warszawa.
- Trzaskalik, T. (2014b). Wielokryterialne wspomaganie decyzji, Przegląd metod i zastosowań, Zeszyty Naukowe Politechniki Śląskiej. Seria: Organizacja i Zarządzanie, 74, 239–263.
- VOSviewer (version 1.6.17, February 19, 2024). Centre for Science and Technology Studies, Leiden University, The Netherlands. <https://www.vosviewer.com>
- Wanga, L., Zhanga, H., Wanga, J., Li, L. (2017). Picture fuzzy normalized projection-based VIKOR method for the risk evaluation of construction Project, Applied Soft Computing, 64, 216-226. <https://doi.org/10.1016/j.asoc.2017.12.014>
- Xiong, L., Teng, C. L., Zhu, B. W., Tzeng, G. H., Huang, S. L. (2017). Using the D-DANP-mV Model to Explore the Continuous System Improvement Strategy for Sustainable Development of Creative Communities, *International Journal of Environmental Research and Public Health*, 14(11):130. <https://doi.org/10.3390/ijerph14111309>
- Yager, R. R. (2004). Modeling Prioritized Multicriteria Decision Making, IEEE Transactions on systems, Man, and Cybernetics, 34(6), 2396-2404.
- Yager, R. R. (2018). Categorization in multi-criteria decision making, Information Sciences, 460-461, 416-423. <http://dx.doi.org/10.1016/j.ins.2017.08.011>
- Yazdani, M., Zolfani, S. H., Zavadskas, E. K. (2016). New integration of MCDM methods and QFD in the selection of green suppliers. Journal of Business Economics and Management, 17(6), 1097–1113. <https://doi.org/10.3846/16111699.2016.1165282>
- Yu, Q., Hou, F. (2016). An approach for green supplier selection in the automobile manufacturing industry, Kybernetes, 45(4), 571-588. <https://doi.org/10.1108/K-01-2015-0034>
- Yu, D., Xu, Z., Wang, W. (2018). Bibliometric analysis of fuzzy theory research in China: A 30-year perspective, Knowledge-Based Systems, 141, 188-199. <http://dx.doi.org/10.1016/j.knosys.2017.11.018>
- Zadeh, L. A. (1965). Fuzzy sets. Information and Control, 8 (3), 338-353. [https://doi.org/10.1016/S00199958\(65\)90241-X](https://doi.org/10.1016/S00199958(65)90241-X)
- Zavadskas, E. K., Turskis, Z. (2011). Multiple criteria decision making (MCDM) methods in economics: an overview. Technological and Economic Development Economy, 17(2), 397-427. <https://doi.org/10.3846/20294913.2011.593291>
- Zyoud, S. H., Fuchs-Hanusch, D. (2017). A bibliometric-based survey on AHP and TOPSIS techniques. Expert Systems with Applications, 78, 158-181. <https://doi.org/10.1016/j.eswa.2017.02.016>
- Zopounidis, C., Doumpos, M. (2017). Multicriteria decision making: Applications in Management and Engineering, Springer, Heidelberg.