SCIENTIFIC OASIS

Decision Making: Applications in Management and Engineering

Journal homepage: www.dmame-journal.org
ISSN: 2560-6018, eISSN: 2620-0104

Mapping the Evolution of Multi-Attributive Border Approximation Area Comparison (MABAC) Method: A Bibliometric Analysis

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ARTICLE INFO

Article history:
Received 17 February 2023
Received in revised form 29 November 2023
Accepted 5 December 2023
Available online 8 December 2023

Keywords: MABAC; Bibliometric Analysis; Biblioshiny; VOSviewer.

ABSTRACT

This paper presents a comprehensive bibliometric analysis of Multi-Attributive Border Approximation Area Comparison (MABAC) method using the Biblioshiny application of the bibliometrix package, R program and VOSviewer tools to provide a holistic view of the research landscape by identifying its evolution, major contributors and most influential research areas. The study, analyzing 264 articles from the Scopus database (January 2015 to September 2023), reveals China as the leading contributor, with India spearheading international collaboration. The most impactful publication, "The selection of transport and handling resources in logistics centres using MABAC," by Pamučar and Ćirović [2], boasts 537 citations. Notably, the "University of Defence in Belgrade" is a prominent institution in this domain. "Pamučar D" emerges as the most cited author. Key terms include "MABAC," "MABAC method," and "MCDM," commonly associated with MABAC method. The top three cited journals are "Expert Systems with Applications," "Decision Making: Applications in Management And Engineering," and "Symmetry." The study provides valuable insights for researchers, practitioners, and decision-makers interested in MABAC's applications and future developments in MCDM, contributing to ongoing discussions about its relevance.

1. Introduction

Decision making is a fundamental concept in various fields, including business, engineering, public policy, and more. It involves a cognitive process that encompasses the selection of a course of action from a range of available alternatives. MCDM is an extension of traditional decision making that considers multiple criteria, often conflicting, in the decision process. It aims to find a compromise or optimal solution that balances these diverse criteria. MCDM involves the process of selecting the best course of action or alternative from a finite set, often when faced with conflicting objectives or criteria to consider [1].

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https://doi.org/10.31181/dmame7120241037

MCDM methods involve several key steps including step 1: Defining the MCDM problem precisely and identify the decision criteria; step 2: Giving weightage to the criteria. Once the decision criteria have been identified, each criterion is assigned a weight according to its relative value. This can be done using various approaches such as pairwise comparisons or rating systems; Step 3: Identifying alternatives: This involves the process of identifying a group of alternatives that can be used in the decision-making process. This requires the compilation of a list of all feasible options; Step 4: Evaluating alternatives: This involves comparing each alternative against the decision criteria. This entails calculating how well each alternative fulfills each condition and giving each alternative a score based on its performance; Step 5: Calculating overall score for each alternative: After evaluating the alternatives against the decision criteria, the next step is to sum the scores for each criterion to obtain an overall score for each alternative. This can be achieved using various aggregation methods; Step 6: Performing sensitivity analysis: To assess the robustness of the decision-making process, the influence of changes in the weights of the selection criteria and the evaluation scores of the alternatives is tested using sensitivity analysis and; Step 7: Making a decision based on aggregated scores of the alternatives and ranking the alternatives: This involves selecting the alternative with the highest overall score.

Bibliometric analysis has emerged as an indispensable tool in academic research and scientific evaluation. It allows us to examine the complex network of scientific literature in a given field of study, revealing patterns, trends, and important influencers. In the field of decision science and MCDM, Multi-Attributive Border Approximation Area Comparison (MABAC) method has attracted increasing interest and acclaim due to its versatility and applicability. MABAC, a powerful method for addressing complex decision-making scenarios, has witnessed a steady increase in research interest over the years. Researchers and practitioners from a variety of disciplines have recognized its potential to aid critical decision processes. MABAC method provides a comprehensive evaluation by considering multiple attributes simultaneously. This allows for a more holistic assessment of alternatives or decision criteria. The method often involves graphical representation, such as polygonal areas, making it visually intuitive for decision-makers to understand the relationships and trade-offs among different attributes. The method facilitates the identification of preferred alternatives by comparing the relative positions of alternatives in the multi-attribute space. This aids in selecting the most suitable alternative based on the specified criteria. As MABAC method continues to evolve and adapt to new challenges, it becomes imperative to examine its academic environment through a bibliometric lens, providing valuable insights into its development, impact and prospects. The objective of this in-depth bibliometric analysis is to present a comprehensive overview of the academic development of MABAC method. This study uses Biblioshiny, a web-based bibliometric analysis platform, to collect and process a large number of academic publications related to MABAC method. Biblioshiny facilitates data collection, cleaning and visualization by providing information on the chronological evolution of research, leading authors, journals and keywords. Furthermore, VOSviewer, a sophisticated network visualization tool, is used to create co-authorship and co-citation networks, shedding light on the collaborative nature of MABAC research and the significant contributions made by key researchers. In addition, keyword co-occurrence analysis reveals emerging trends and research themes within MABAC field.

The organizational structure of the paper is as follows: Section 2 introduces MABAC method, incorporating elements such as bibliometric analysis, research gaps, and relevant research issues. Section 3 delineates the research strategy employed in this study. Section 4 encapsulates and evaluates the findings, concurrently providing a comprehensive overview of research themes and

trends pertinent to MABAC method. Discussion is presented in Section 5, while potential avenues for future research are explored in Section 6, thereby fostering a deeper understanding.

2. MABAC Method

2.1 Fundamentals of MABAC Method

MABAC method was introduced to the literature by Pamučar & Ćirović [2] for ranking alternatives. The technique is based on computing criterion functions for each option and determining the distances of the alternatives to the border approximation area. The method's steps are as follows [2]:

Step 1: Creation of the decision matrix. A decision matrix (X) consisting of m alternatives and n criteria is determined.

$$X = \left[x_{ij}\right]_{mxn} = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \; i = 1,2,\dots,m \;\; j = 1,2,\dots,n$$

x_{ij}: i. alternative's performance in criterion j.

Step 2: Normalisation of the decision matrix. In order to make the criteria in different units suitable for comparison, a normalised decision matrix (N) is obtained by taking values in the range [0,1].

$$N = \begin{bmatrix} n_{11} & \cdots & n_{1n} \\ \vdots & \ddots & \vdots \\ n_{m1} & \cdots & n_{mn} \end{bmatrix}$$

Equation (1) and (2) are used according to the direction of the criterion.

If the direction of the criterion is maximisation (benefit); $n_{ij} = \frac{x_{ij} - x_i^-}{x_i^+ - x_i^-}$ (1)

If the direction of the criterion is minimisation (cost); $n_{ij} = \frac{x_{ij} - x_i^+}{x_i^- - x_i^+}$ (2)

x_i^+: maximum value in the columns

x_i^-: minimum value in the columns

Step 3: Weighting the decision matrix. Equation (3) is applied for weighting the decision matrix.

$$v_{ij} = w_i.(n_{ij} + 1) \quad (3)$$

Step 4: Obtaining the boundary proximity area matrix (G). The boundary proximity area value (g_i) Equation (4) is applied.

$$g_i = \left(\prod_{j=1}^{m} v_{ij}\right)^{1/m} \quad (4)$$

m: number of alternatives

$G = (g_1 \quad g_2 \quad \cdots \quad g_n)$

Step 5: Distances (Q) between the decision options and the border proximity region are calculated. The distances of the alternatives to the boundary proximity area are obtained by Equation (5).

$$Q = V - G = \begin{bmatrix} v_{11} - g_1 & \cdots & v_{1n} - g_n \\ \vdots & \ddots & \vdots \\ v_{m1} - g_1 & \cdots & v_{mn} - g_n \end{bmatrix} = \begin{bmatrix} q_{11} & \cdots & q_{1n} \\ \vdots & \ddots & \vdots \\ q_{m1} & \cdots & q_{mn} \end{bmatrix} \quad (5)$$

Step 6: Identifying the state of choice options about the border proximity region. Each decision alternative (A_i), can be located in the boundary proximity area (Ω), in the upper proximity area (Ω^+)or in the lower proximity area (Ω^-). For a decision alternative to be the best alternative, most of the values related to the criteria must be in the upper proximity area (Ω^+). The proximity areas are given in Figure 1.

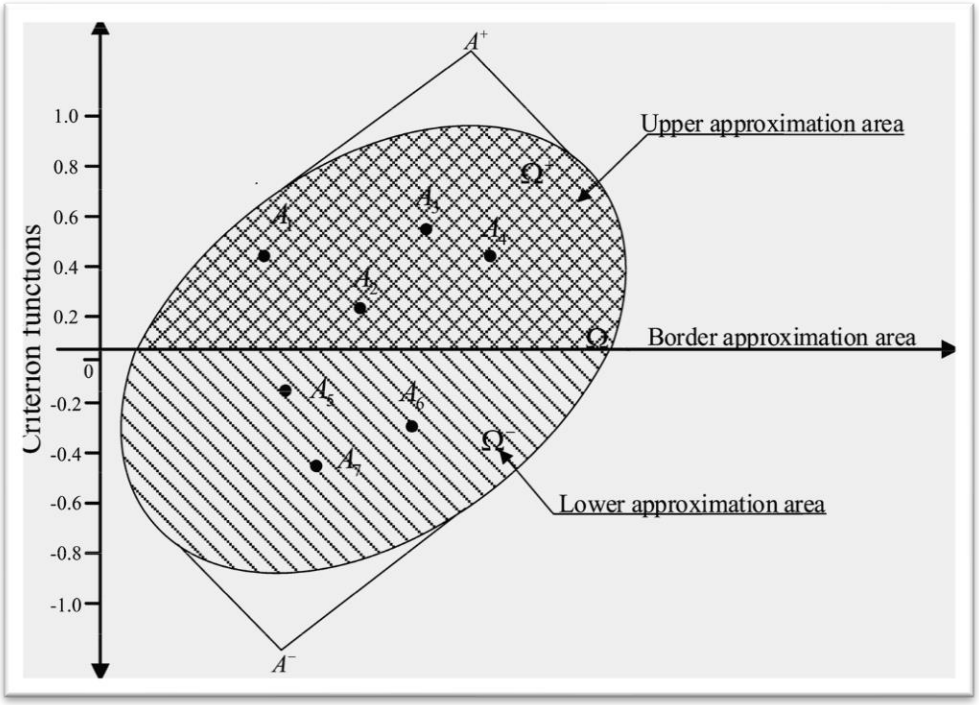

Fig. 1. Boundary Proximity Areas

$q_{ij} > 0$ The proximity of alternatives A_i to the best substitute

$q_{ij} < 0$ Equation (6) depicts how near alternative A_i is to the negative ideal alternative.

$$A_i \in \begin{cases} \Omega^+ \; eğer \; q_{ij} > 0 \\ \Omega \; eğer \; q_{ij} = 0 \\ \Omega^- \; eğer \; q_{ij} < 0 \end{cases} \quad (6)$$

Step 7: Ranking of decision alternatives. Equation (7) is used for ranking.

$$S_i = \sum_{j=1}^{n} q_{ij} \quad j = 1,2,\dots,n \; ve \; i = 1,2,\dots,m \quad (7)$$

2.2 Methods used in Conjunction with MABAC Method

An important topic in MCDM domain is the weighting of criteria. The purpose of criterion weighting is to express the importance of each criterion relative to the other. The determination of criterion weights is based on two main sources: the perspectives and judgments of the decision

makers or their direct inference from the decision matrix itself. MCDM weighting methodologies are classified as follows:

i. The determination of criteria weights solely through the opinions, perceptions and judgments of decision-makers is referred to as subjective weighting methods. Examples of these methods include Analytical Hierarchy Process (AHP) [3,4], Analytic Network Process (ANP) [5], Decision Making Trial and Evaluation Laboratory (DEMATEL) [6], Best Worst Method (BWM) [7], Full Consistency Method (FUCOM) [8] and vital-immaterial mediocre method (VIMM) [9].
ii. Objective weighting methods enable the weights to be obtained from the decision matrix in various mathematical ways which include Entropy [10], criterion importance through correlation between criteria (CRITIC) method [11], level-based weight assessment (LBWA) [12] and method based on the removal effects of criteria (MEREC) [13].
iii. Methodologies that combine objective and subjective weighting techniques to calculate criterion weights are called integrated methods. These approaches optimize the available information by combining the strengths of both paradigms. Integrated determination of objective criterion weights (IDOCRIW) [14] and objective-subjective weighting method to minimize inconsistency (OSWMI) [15] are examples of integrated weighting methods [16].

In "Step 3," of MABAC method, one of the weighting techniques is employed to generate the criteria weights. The key contribution of such techniques is the development of an integrated ranking results as well as the determination of the criteria weights. Figure 2 depicts the frequency of MCDM weighting techniques used to compute criteria weights in MABAC method for various problems.

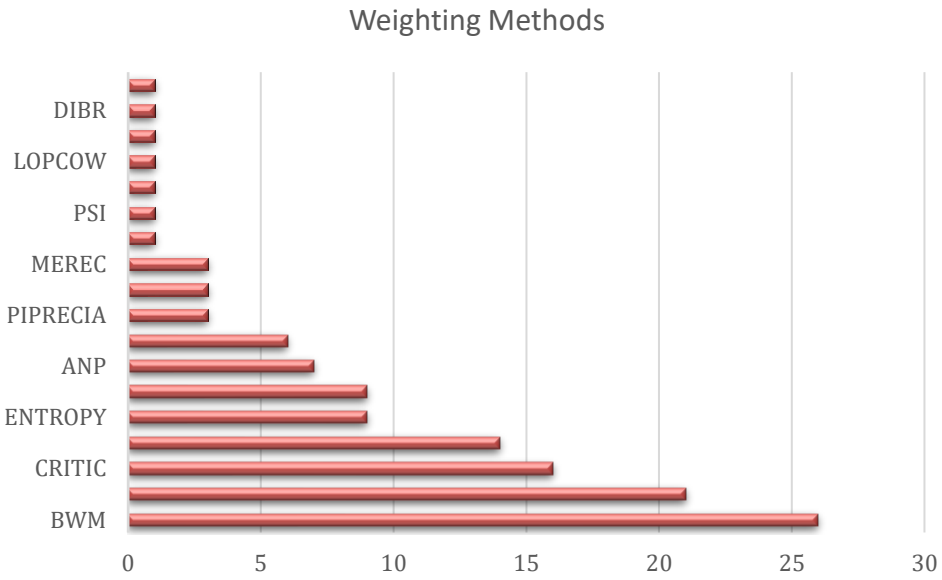

Fig. 2. MCDM Methods for calculating criteria weights in conjunction with MABAC method

BWM is employed in combination with MABAC method in 26 papers. Furthermore, AHP and DEMATEL are the methods used to calculate the weights in MABAC method in 21 and 14 articles, respectively.

In decision-making scenarios, the primary objective is to determine the optimal alternative and establish a ranking from favorable to unfavorable. Multi-Attribute Utility Theory (MAUT) [17], Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) [18], Additive Ratio Assessment (ARAS) [19], Measurement of Alternatives and Ranking According to Compromise Solution (MARCOS) [20], Compromise Ranking of Alternatives from Distance to Ideal Solution

(CRADIS) [21], Weighted Aggregated Sum Product Assessment (WASPAS) [22], Multi-Attributive Ideal Real Comparative Analysis (MAIRCA) [23], Tomada de Decisão Interativa Multicritério (TODIM) [24], and Combined Compromise Solution (CoCoSo) [25,26] represent examples of ranking methods. Figure 3 illustrates the frequency of MCDM ranking methods frequently integrated with MABAC method.

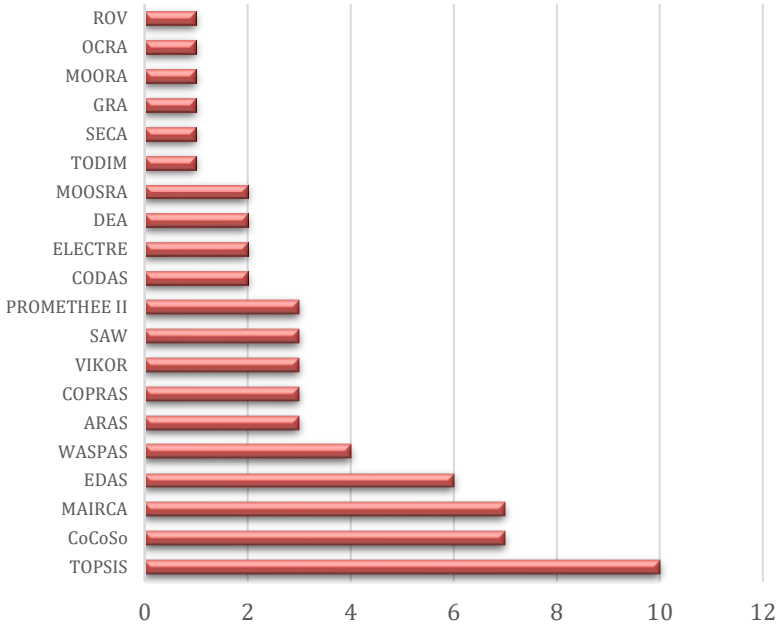

Fig. 3. Other MCDM Methods frequently combined with MABAC method

TOPSIS, a very popular MCDM method, has been founds in 10 articles where it is utilized in conjunction with MABAC method. CoCoSo and MAIRCA are the other favored methods for ranking, along with MABAC method, as evidenced in 7 articles.

2.3. Use of Uncertainty Sets in MABAC Method

The use of uncertainty sets is an important extension of original MCDM methods to handle ambiguous, and incomplete information in decision-making problems. Figure 4 shows the forms of uncertainty sets used in MABAC method to handle uncertain situations. Out of 264 research, 126 used MABAC method with various forms of uncertainty sets. Among all uncertainty sets, neutrosophic fuzzy sets have the largest proportion. The hesitant fuzzy sets and intuitive fuzzy sets are the second and third most widely utilized uncertainty models using MABAC method, respectively.

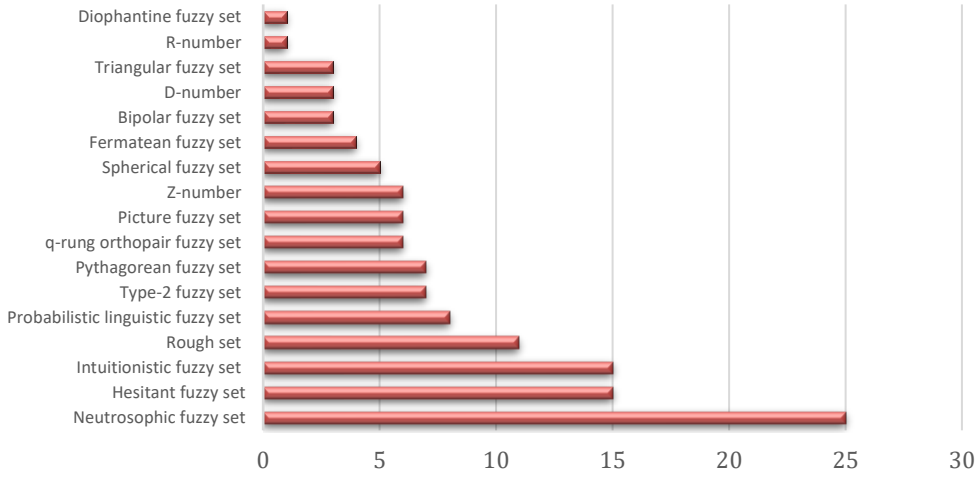

Fig. 4. Integration of uncertainty sets in MABAC method

2.4. Bibliometric analysis

Bibliometrics is a quantitative assessment of bibliographic data that provides a systematic and data-driven method to understanding the research environment. Bibliometric analysis is a powerful technique for tracking research trends and keeping track of discoveries. Bibliometric analysis has found widespread use in a variety of study domains. Among these fields, bibliometric analysis has scanned works relevant to MCDM, particularly in decision-making research. Bibliometric analysis plays a significant role in comprehensively understanding the existing literature. It enables researchers to identify key contributors, seminal works, and emerging themes within the field of MCDM. This approach not only aids in mapping the intellectual structure of the research but also facilitates the identification of influential publications, authors, and research clusters. For example, Zaliluddin [27] conducted a bibliometric study focusing on the study of fuzzy logic and MCDM. They analyzed articles published in Scopus between 1984 and 2022. Vatankhah et al. [28] performed travel and tourism bibliometric study, as well as MCDM investigations. They looked at publications from Web of Science and Scopus between 1997 and 2022. Liao et al. [29] conducted bibliometric research on Fuzzy MCDM, hospitality, and tourism. They looked at papers from Web of Science between 1997 and 2022. Herawan et al. [30] completed bibliometric research with MCDM and tourism study. They analyzed the articles published in Scopus between 2013 and 2023. Nirmal et al. [31] conducted bibliometric research focusing on Fuzzy MCDM and green supply chain study. They analyzed the articles published in Scopus between 2010 and 2023. There are also bibliometric analyses specific to MCDM methods in the literature. Sohail et al. [32] conducted a bibliometric study focusing on the study of MCDM-based waste management models. They analyzed articles published in Scopus between 1992 and 2022. Xu and Xu [33] conducted a bibliometric analysis of decision-making in health management. They used data from the WoS database between 1998 and 2021. The bibliometric analyses of MCDM approaches are summarised in Table 1. This table shows the bibliometric analyses performed at different time intervals specific to MCDM approaches.

Table 1
Bibliometric analyses specific to MCDM methods

Authors	Year	Keyword	Time Span	Number of Publications Reviewed	Database	Software used
Demir et al. [16]	2023	Sensitivity Analysis	2000-2023	1374	Scopus	VOSviewer, Biblioshiny and CiteSpace
Ayan & Abacıoğlu [34]	2022	WASPAS, MABAC, EDAS, CODAS, COCOSO, and MARCOS	2012-2022	1215	Web of Science and Scopus	Biblioshiny
Koca & Yıldırım [1]	2021	DEMATEL	1999-2020	1963	Web of Science	Biblioshiny
Ferreira & Santos [35]	2021	MACBETH	1994-2016	192	Scopus	VOSviewer
Chen et al. [36]	2019	ANP	1997-2018	1485	Web of Science	VOSviewer
Zyoud & Fuchs-Hanusch [37]	2017	AHP and TOPSIS	1976-2015	TOPSIS: 2412 AHP:10188	Scopus	VOSviewer
Present study		MABAC	2015-2023	264	Scopus	VOSviewer and Biblioshiny

2.4. Research Gaps and research questions

A thorough analysis of existing academic publications on MABAC method identifies two key research gaps as follows:

i. No prior bibliometric study has been found on MABAC method.
ii. The absence of a universally recognized model for evaluating research methodologies within MCDM poses a significant gap.

To address these gaps, a research initiative was undertaken utilizing R software and focusing on bibliometric analysis of MABAC method related publications in the Scopus database. The ensuing insights are visualized using VOSviewer, establishing a conceptual framework and highlighting impactful articles and prolific contributors related to MABAC method. The study established a conceptual framework for MABAC method related publications and identified the most impactful articles and prolific contributors. The findings of this study serve as a navigational guide for researchers in the field of MCDM, providing a deep insight into both current and future research trends.

This is the first bibliometric study of its sort to evaluate MABAC method. The main purpose of this research is to find answers to the questions identified:

i. Explore the trajectory of growth and the citation status of articles related to MABAC method.
ii. Identify the most cited authors, contributing to MABAC literature.
iii. Determine the most cited publications, journals, organizations, and countries associated with MABAC method.
iv. Investigate the primary research areas and topics within the applications of MABAC method.
v. Pinpoint the specific publication that has received the highest number of citations in the context of the MABAC method.
vi. Analyze the prevalent integration patterns of other MCDM methods with MABAC.

This study endeavors to shed light on the conceptual intricacies inherent in research utilizing MABAC method, thereby contributing to an enriched understanding of both contemporary and prospective research trajectories within the domain of MCDM. Through a comprehensive exploration of MABAC method, coupled with the application of bibliometric analysis and a focus on addressing research gaps and pertinent issues, this research serves to provide valuable insights for the pursuit of further investigations.

3. Materials and Methods

The process steps in bibliometric analysis are as follows:

Step 1: Selection of a database.

Because of its broader coverage, the Scopus database was predominantly employed in this study. Scopus is a comprehensive database covering dozens of different types of academic publications, including scientific journals, conference proceedings and books. Scopus analyzes the effect and influence of scientific papers and authors using bibliometric measures such as h-index, co-citation networks and citation counts. It makes it easier to identify and follow research trends and patterns of collaboration across disciplines, institutions, and countries. Scopus also employs sophisticated data validation techniques to ensure the accuracy and completeness of bibliographic data, establishing it as a reliable source for bibliometric research [38].

Step 2: Filtering and downloading data from the database.

Filtering is used to get information from the specified database. The query in Table 2 gives you access to data from the Scopus database.

Table 2
Filtering information in the Scopus database

Included	Keywords Used: MABAC Document Type: Article Publication Language: English Form of publication: Journal Year of publication: 2015-2023
Excluded	Review and conference proceedings, book chapters, articles, or reviews published on preprint websites, as well as comments, editorials, and letters

The date for the query was set as January 2015-2023 and the data were downloaded on 20 September 2023. For the compilation of a bibliometric analysis of 264 scientific articles, inclusion and exclusion criteria were used. The data were downloaded in .csv format and sorted from most cited to least cited. The bibliometrics and VOSviewer package in R was used to load the complete file in standard .csv format.

Step 3: Choosing the bibliometric analytic methodologies to utilize.

The R bibliometrics library [39] was used for bibliometric analysis in this study. The findings were shown using VOSviewer software [40]. Figure 5 depicts a flow chart of the data-gathering procedure.

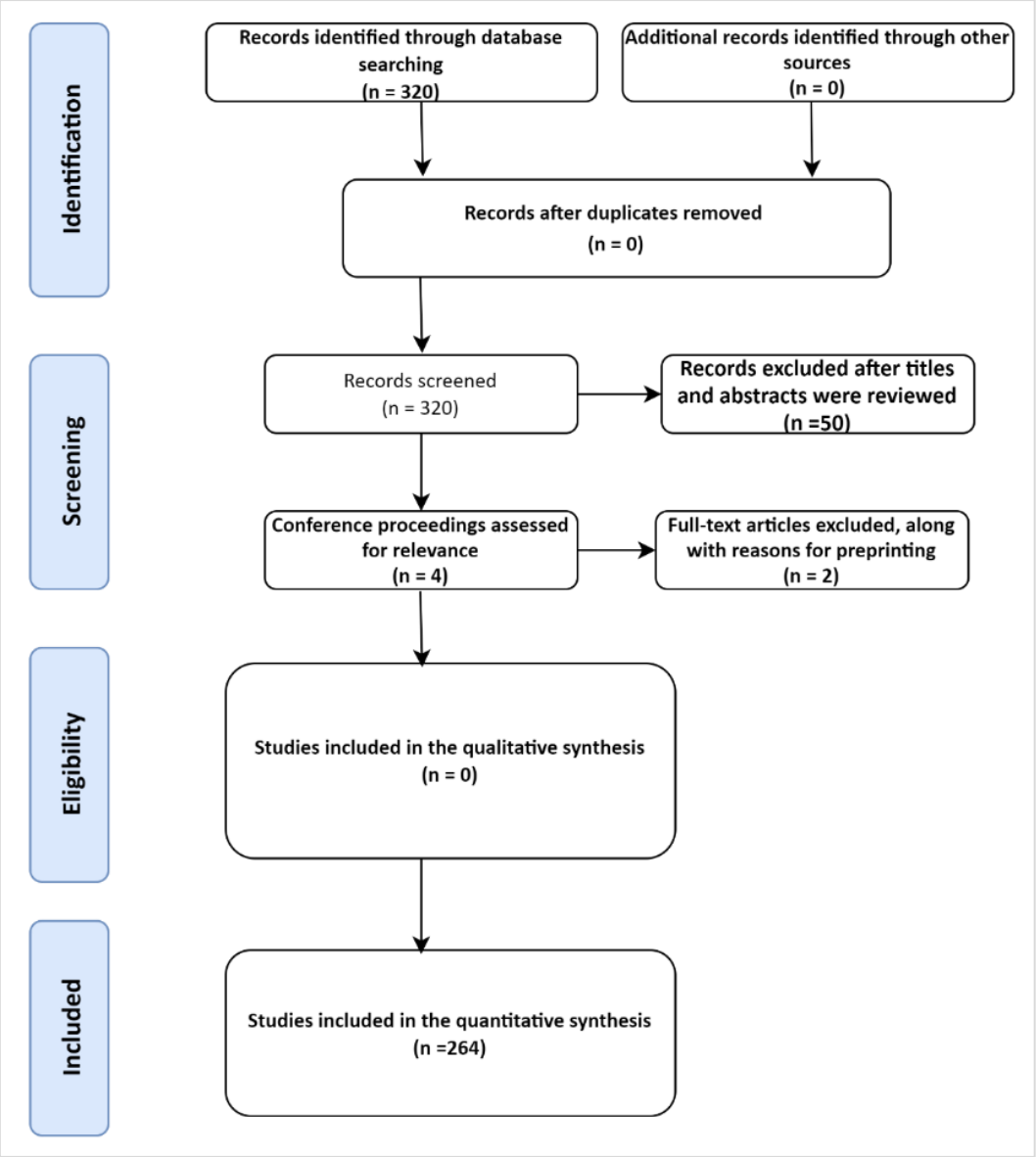

Fig. 5. PRISMA flow diagram of data collection process

The four phases of the data search were identified, screening, eligibility, and inclusion criteria, as shown in Figure 5. In the first phase, 320 records were screened. Other sources did not provide additional records. Of the records screened, 56 were deleted in the second phase. The third phase revealed that no further research had been incorporated into this qualitative synthesis. The evaluation comprised 264 studies in the final phase of the quantitative synthesis.

4. Bibliometric analysis results of the MABAC method

4.1. Performance Analysis

A comprehensive descriptive analysis of publications was carried out, in addition to an assessment of the annual publication growth rate and an estimate of the average number of citations per publication. A Sankey diagram is used to compare the three separate domains, such as determining which journal has the most publications and citations and which organization and document has the most publications and citations. In addition, the study identifies and assesses the

author and nation with the highest output in terms of publications and citations, as well as data performance analysis.

4.1.1 Overall review of the database

MABAC method produced by Biblioshiny was subjected to descriptive analysis. Figure 6 illustrates the data file's main information.

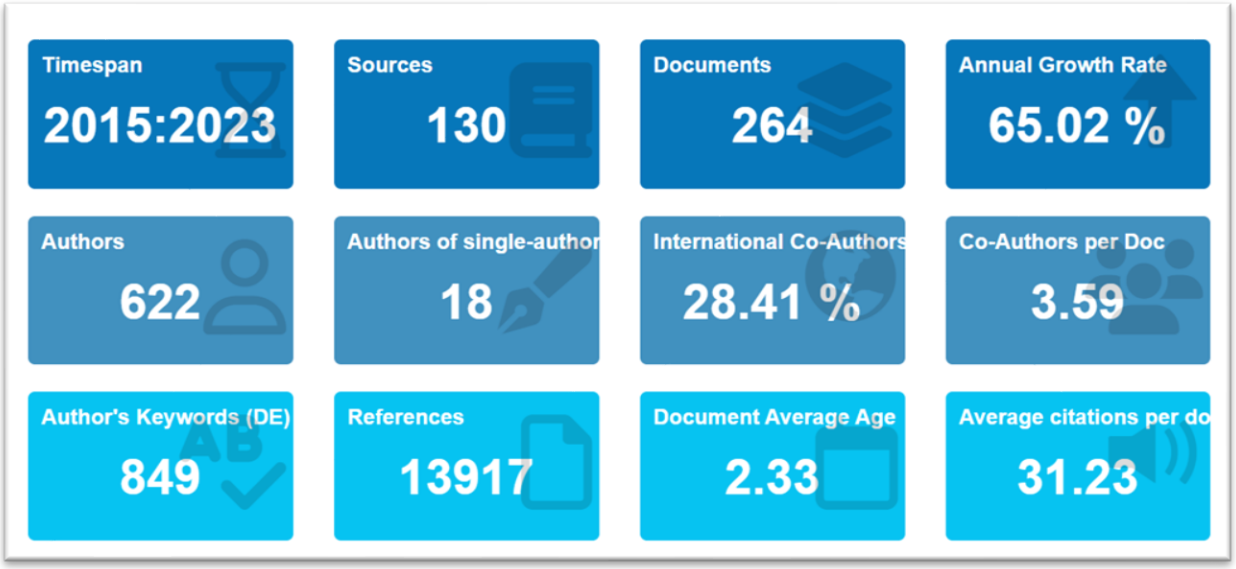

Fig. 6. Main information

Between 2015 and 2023, 264 articles on the MABAC method were evaluated in 130 sources (journals, books, etc.) in the Scopus database. Publications rose at a 65.02% yearly pace, with the average age of the publications being 2.33 years and each receiving an average of 31.23 citations. 18 of the 622 writers were published as single author. International co-authorship in the documents accounts for 28.41% of the total.

4.1.2. Annual publication increase

Figure 7 displays the progression of documents in the bibliometric analysis of MCDM research using MABAC method throughout time. According to Figure 7, there is a growing interest among scientists worldwide for analyses with MABAC. The number of publications has increased over time, with 55 publications in 2023, 46 in 2022, 51 in 2021, 39 in 2020, 34 in 2019, 23 in 2018, 13 in 2017, 2 in 2016 and 1 in 2015. In particular, 2023 was the year with the highest increase in MCDM research on analyses conducted with MABAC method.

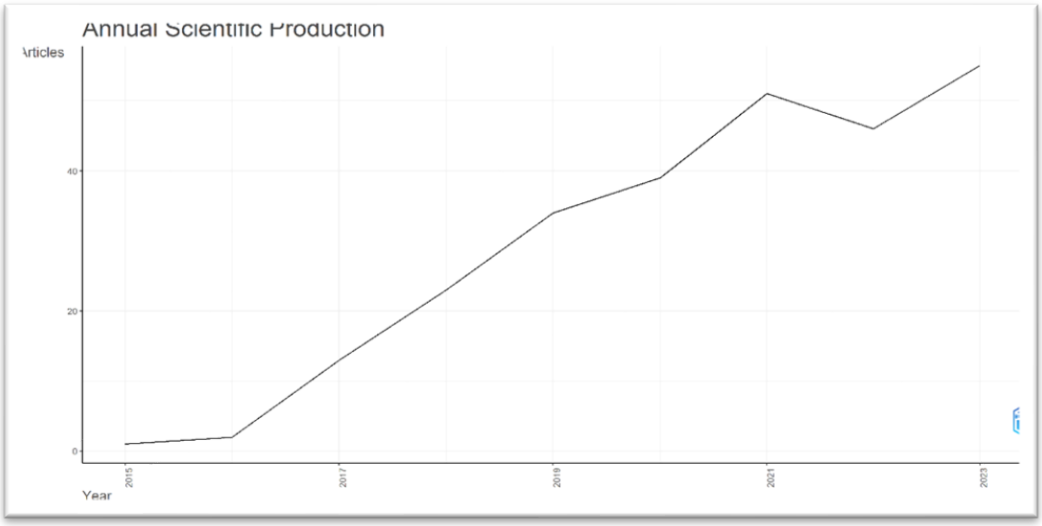

Fig. 7. Distribution of MABAC studies used in the research according to years

4.1.3. Average annual citations

Figure 8 depicts the status of yearly citations in the bibliometric analysis of MCDM research with MABAC method.

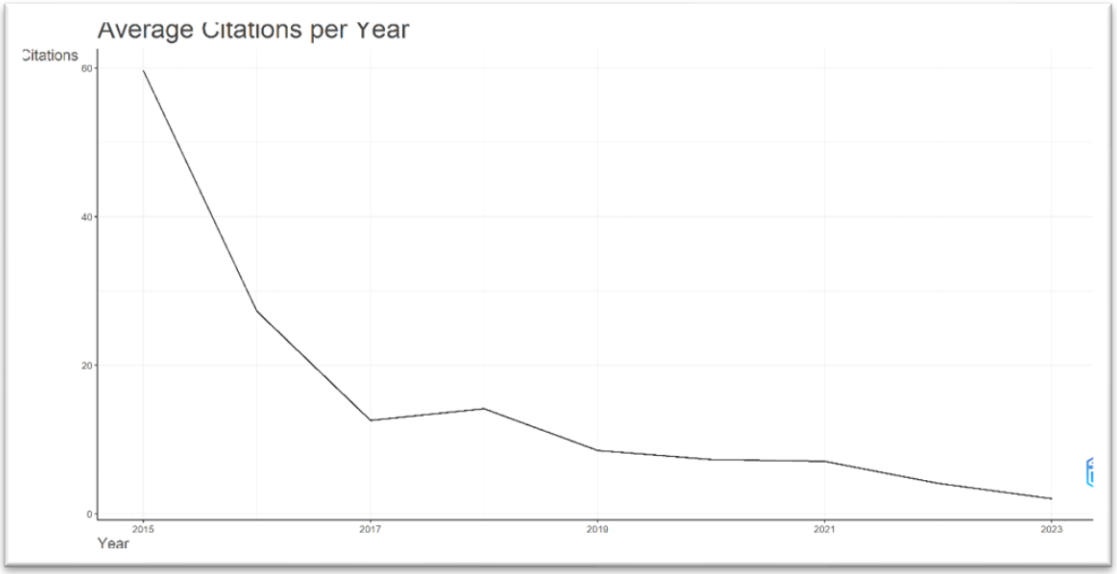

Fig. 8. Annual average citation growth trend of studies conducted with MABAC method

According to Figure 8, the quantity of citations is decreasing year after year. 2.05 in 2023, 4.1 in 2022, 7.09 in 2021, 7.32 in 2020, 8.54 in 2019, 14.18 in 2018, 27.31 in 2016, and 59.67 in 2015. In 2015, the average total number of citations per publication in research employing MABAC method was 537.

4.1.4. Sankey diagram

The three parameters to be related (journal, author, and keyword) are specified by the software in this "Three-Field Plot" layout, Figure 9 shows the most important ones for each parameter.

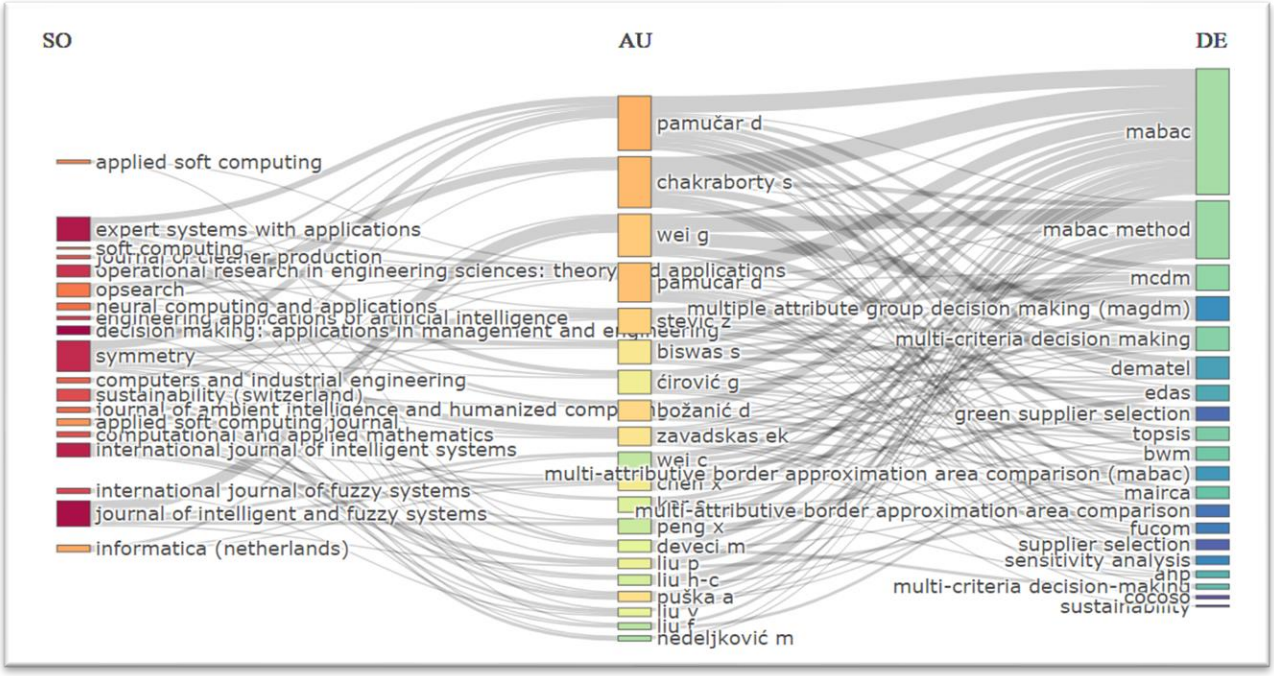

Fig. 9. Three-Field Plot (source, author and keyword)

The box sizes in Figure 7 show the strength of the relationship between the components. The size of the boxes in this graphic corresponds to the literature's influential characteristics. The leading journal is "Symmetry", the leading author is "Pamučar D. " and the leading keyword is "MABAC".

4.1.5. Most cited and most published journals

Table 3 shows the ranking of MABAC method sources of publications based on total citations (TC).

Table 3
Most cited references for MABAC method

Source	Total citation (TC)	Number of publications (NP)
Expert Systems with Applications	1155	9
Decision Making: Applications in Management And Engineering	701	16
Symmetry	607	9
International Journal of Intelligent Systems	540	9
Computers and Industrial Engineering	381	4
Applied Soft Computing Journal	332	3
Journal of Cleaner Production	323	5
International Journal of Fuzzy Systems	284	6
Neural Computing and Applications	263	4
Renewable Energy	236	1

According to Table 3, Expert Systems with Applications ranks first with 1155 citations. Decision Making: Applications in Management And Engineering ranks second with 701 citations and Symmetry ranks third with 607 citations. Decision Making: Applications in Management and Engineering ranks first with 16 articles; Expert Systems with Applications, Symmetry and International Journal of Intelligent Systems rank second with 9 articles.

4.1.6. The affiliations that matter most

The published works produced by the institutions or affiliations of the authors who participated to the study utilizing the MABAC approach are displayed in Table 4.

Table 4
Relevant organizations that have contributed to research with MABAC method

Affiliation	Article
University of Defence in Belgrade	41
Sichuan Normal University	40
Central South Unıversity	36
Shandong University of Finance and Economics	26
Jadavpur University	24
University of East Sarajevo	21
Vilnius Gediminas Technical University	21
National Institute of Technology	20
Shanghai University	14
Southwestern University of Finance and Economics	14

"University of Defence in Belgrade" scored top with 41 publications between 2015 and 2023, "Sichuan Normal University" ranked second with 40 publications, and "Central South University" rated third with 36 publications.

4.1.7. Frequently cited authors

A total of 264 research papers on MABAC method have appeared in different publications, written by a total of 622 people. Table 5 lists the most influential writers in terms of citations and publications worldwide.

Table 5
Number of publications and citations of most prolific authors

Author	TC	NP
Pamučar D.	2621	36
Ćirović G.	1000	7
Zavadskas E.K.	751	10
Stević Ž.	677	11
Peng X.	659	6
Liu H.-C.	463	6
Wang J.-Q.	444	5
Wei G.	414	14
Božanić D.	392	10
Yang Y.	390	4

Pamučar D. ranks first with 2621 citations, Ćirović G. ranks second with 1000 citations, and Zavadskas E.K. ranks third with 751 citations. Pamučar D. ranks top with 36 articles, Wei G. ranks second with 14 articles, and Stević Ž. ranks third with 11 articles.

4.1.8. The most productive countries

The countries with the most publications are listed in Table 6.

Table 6
Countries by number of publications

Country	Article
China	306
India	143
Serbia	119
Iran	63
Turkey	55
Lithuania	25
UK	14
Egypt	12
Algeria	11
Chile	11

Table 6 shows the 10 most efficient countries broadcasting with the MABAC method. As seen in the table, the most productive country is China (306). China is followed by India (143), Serbia (119) and Iran (63). The world density map for the studies conducted with MABAC method is shown in Figure 10.

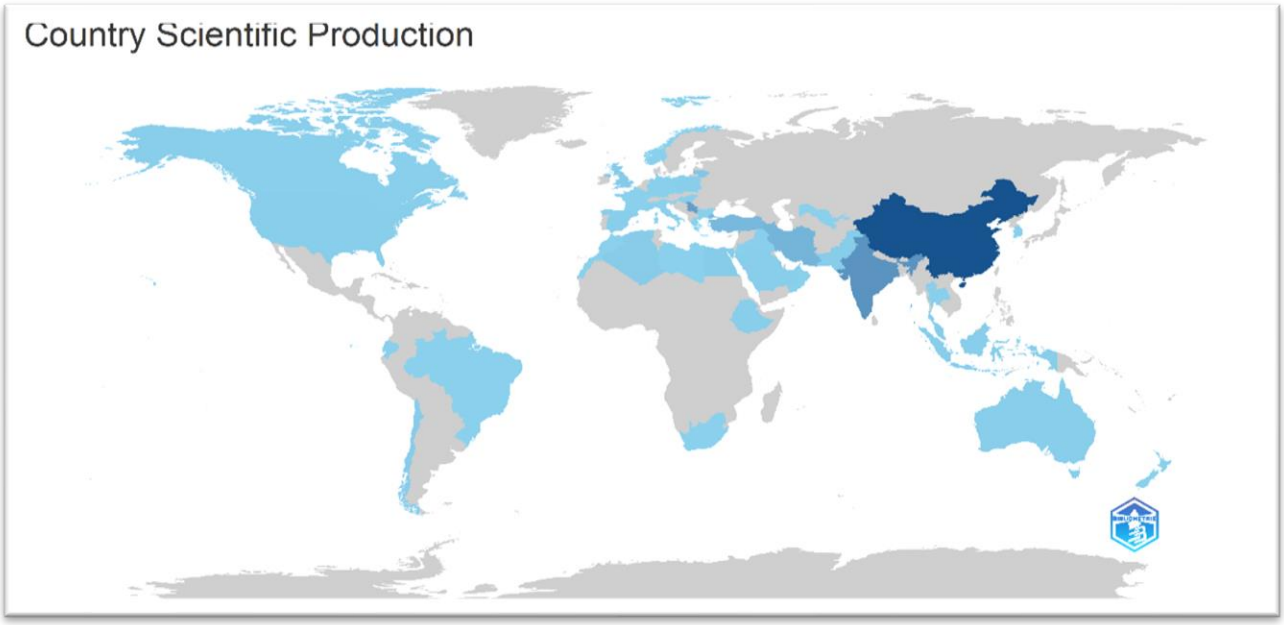

Fig. 10. Country scientific production

On the map, the dark blue (China), blue (India, Serbia, Iran, Turkey, Lithuania, UK...), and grey colors represent the nation that publishes the most, the country that publishes the least, and the country that does not publish. Table 7 lists the 10 countries that have co-operated on the most papers.

Table 7
Co-operating countries and number of publications

From	To	Frequency
India	Serbia	7
Serbia	Lithuania	7
Serbia	Turkey	6
India	Lithuania	4
Turkey	United Kingdom	4
China	Canada	3
China	United Kingdom	3
India	Saudi Arabia	3
Iran	Chile	3
Iran	Lithuania	3

According to Table 7, India-Serbia with 7 documents and Serbia-Lithuania with 7 documents are in the first place among the most co-operated countries. Serbia-Turkey ranks second with 6 documents. India-Lithuania ranks third with 4 documents and Turkey- United Kingdom ranks third with 4 documents. Figure 11 depicts the global co-operation map for these values.

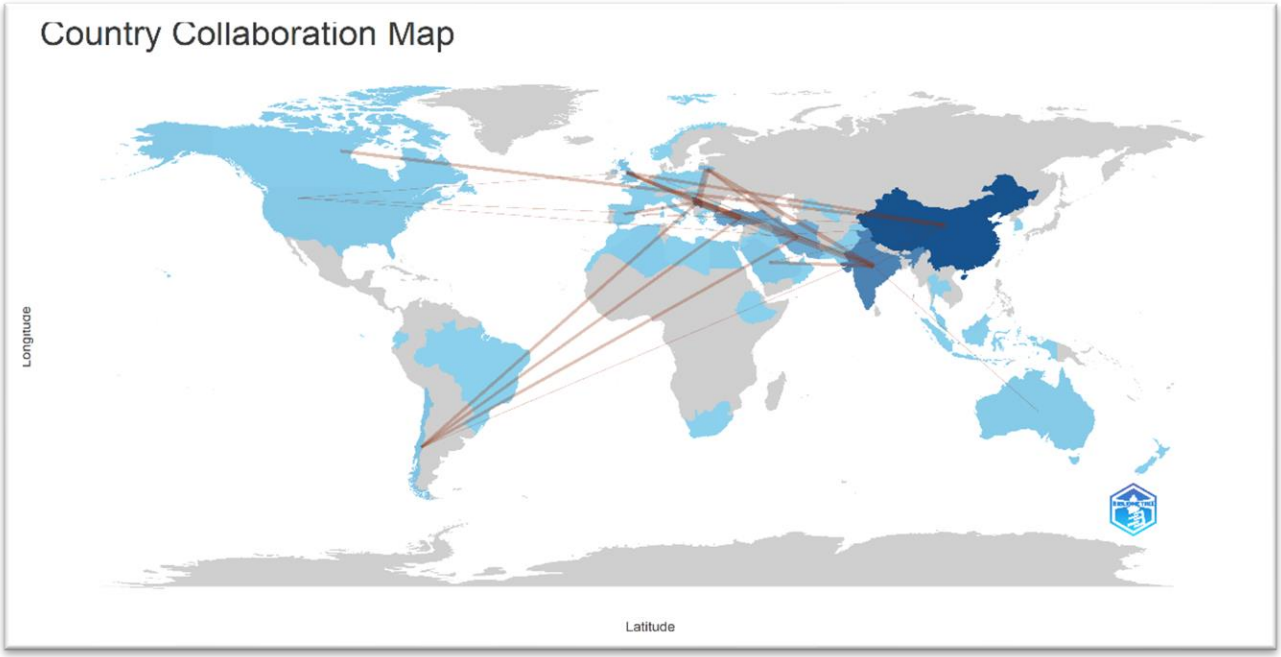

Fig. 11. Country collaboration map

Countries with strong links are those that collaborate the most with others. In studies involving the MABAC method, it is observed that India cooperates with Serbia, Lithuania and Saudi Arabia. It can be said that Serbia cooperates with Turkey and Lithuania. It can be said that India is the country with the most co-operation.

3.1.9. Most cited document

The most fruitful article is the one with the highest citations. Table 8 shows the 10 most productive articles.

Table 8
Most effective documents

Paper	DOI	TC	TC per Year	Normalized TC
Pamučar & Ćirović [2]	10.1016/j.eswa.2014.11.057	537	59,67	1,00
Peng & Yang [41]	10.1002/int.21814	269	33,63	1,23
Gigović et al. [42]	10.1016/j.renene.2016.11.057	236	33,71	2,68
Pamučar et al. [43]	10.1016/j.eswa.2017.08.042	235	39,17	2,76
Peng & Dai [44]	10.1007/s00521-016-2607-y	205	34,17	2,41
Pamučar et al. [45]	10.1016/j.eswa.2017.06.037	172	24,57	1,95
Xue [46]	10.1016/j.asoc.2015.10.010	168	21,00	0,77
Şennaroğlu & Celebi [47]	10.1016/j.trd.2017.12.022	165	27,50	1,94
Gupta et al. [48]	10.1016/j.cie.2019.07.038	144	28,80	3,37

The most cited article is "The selection of transport and handling resources in logistics centres using Multi-Attributive Border Approximation area Comparison (MABAC)" published by Pamučar and Ćirović [2] in Expert Systems with Applications with 537 citations. This article is followed by the article titled "Pythagorean Fuzzy Choquet Integral Based MABAC Method for Multiple Attribute Group Decision Making" published in the International Journal of Intelligent Systems by Peng & Yang [41] with 269 citations. Then, the article titled "Application of the GIS-DANP-MABAC multi-criteria model for selecting the location of wind farms: A case study of Vojvodina, Serbia" ranked third with 236 citations.

4.2. Analysis of Science Mapping

Scientific mapping is the use of computer tools to visualize, analyze, and simulate diverse scientific and technological processes.

4.2.1. Conceptual Structure Map

A conceptual structure map, subject dendrogram, network map based on the author's keywords, and theme map are displayed in this section. A conceptual structural map is depicted in Figure 12.

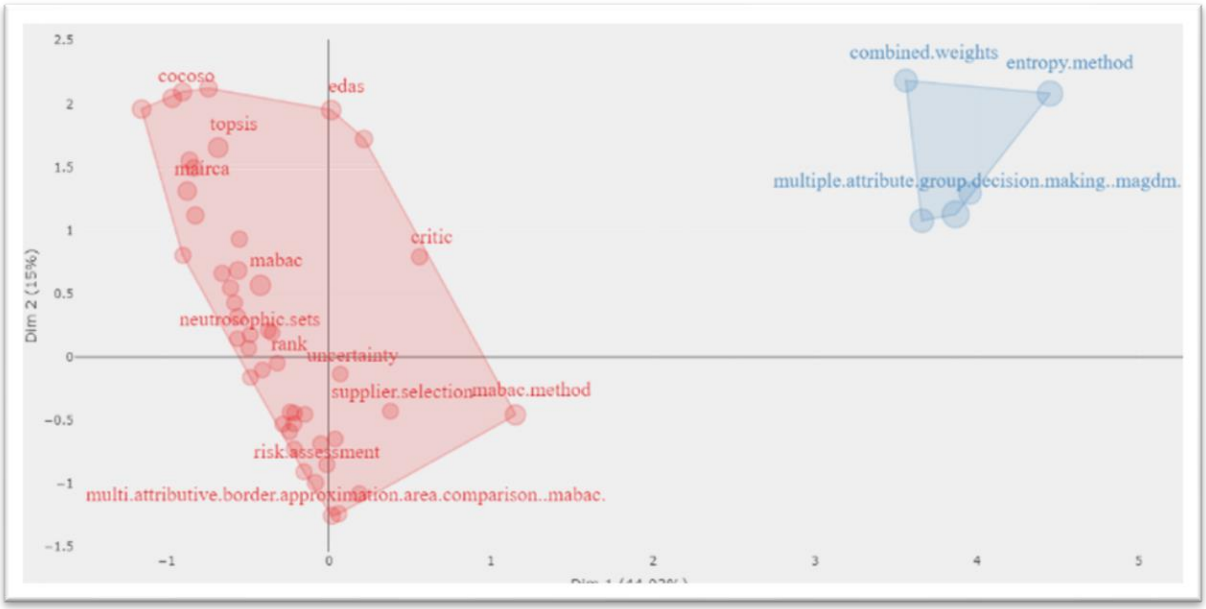

Fig. 12. Conceptual Structure Map

When the keywords of publications connected to MABAC approach are studied using the factor analysis, certain ideas appear in the first cluster with high factor loadings in the first dimension: CoCoSo, EDAS, TOPSIS, MAIRCA, MABAC, CRITIC, neutrosophic sets, rank, uncertainty, risk assessment, supplier selection, MABAC method, multi-attributive border approximation area comparison Keywords related to MCDM are gathered in the red cluster. Multi-attribute group decision-making, combined weights, Entropy method keywords are also collected in the blue cluster.

4.2.2. Thematic map

The thematic search of MABAC articles was conducted using bibliometrics and author's keywords to identify the main review topics of the field. Figure 13 shows that studies on the MABAC method are grouped under four themes, albeit with different intensities.

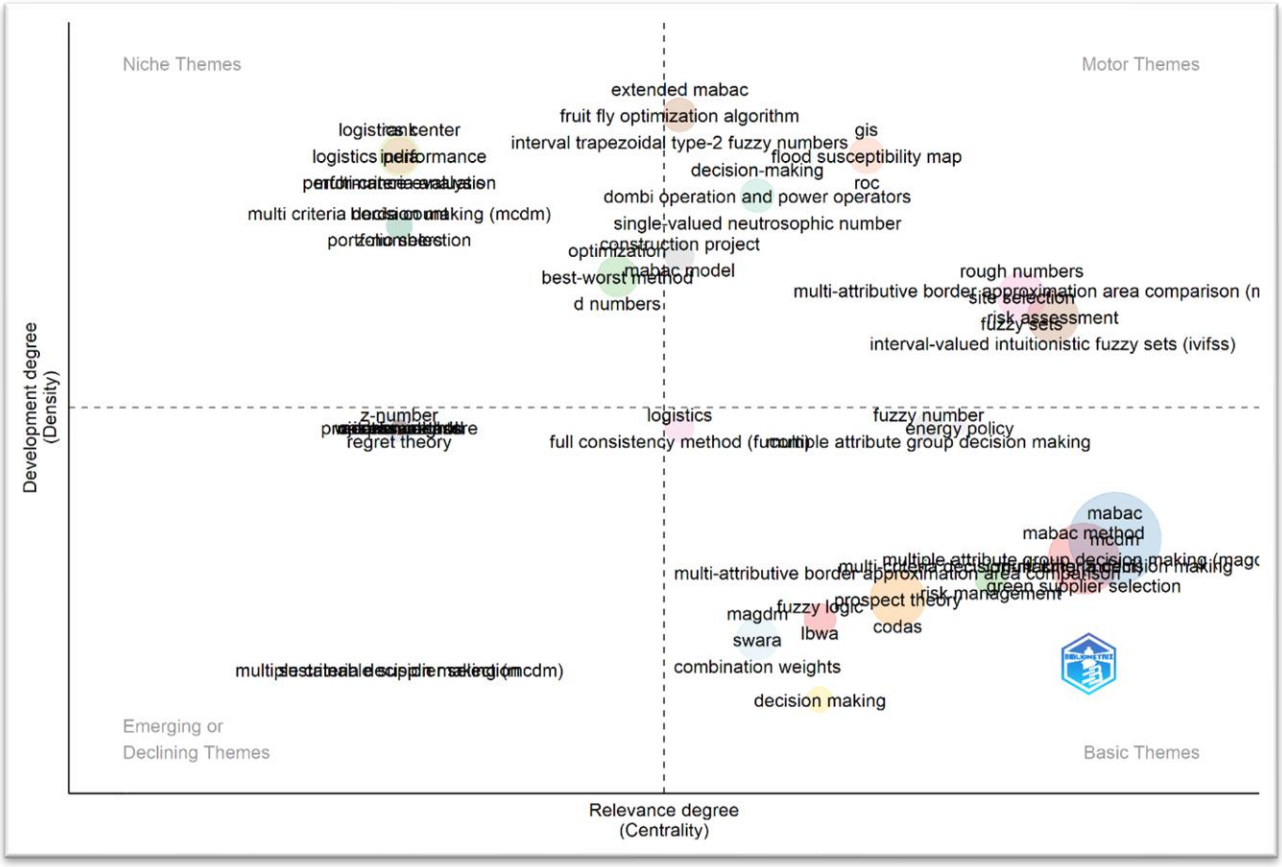

Fig. 13. Thematic map based on keywords

When the author's keywords were taken into account, the niche themes were MCDM and BWM. Emerging themes were z-number and regret theory. The basic (developing) themes were MABAC, fuzzy logic and SWARA. Motor (developed) themes were rough numbers and extended MABAC.

4.2.3. Trend topics

The topics trending in the literature of MABAC method by years from 2015 to 2023 are given in Table 9.

Table 9

Yearly Trending Topics

İtem	freq	year_q1	year_med	year_q3
decision making	173	2019	2021	2022
sensitivity analysis	56	2019	2021	2022
fuzzy sets	38	2019	2021	2021
mabac	31	2018	2019	2022
multicriteria decision-making	25	2020	2022	2023
comparison methods	24	2020	2022	2023
multi-attributive border approximation area comparison	23	2020	2022	2022
behavioral research	15	2019	2020	2022
fuzzy rules	14	2019	2020	2022
rough numbers	14	2018	2020	2022

In the first quarter of 2019, the second quarter of 2021, and the third quarter of 2022, "decision making" was the top trending subject. "Sensitivity analysis" was a hot subject in the first quarters of 2019, 2021, and 2022. Currently, "multi-criteria decision-making" and "comparison methods" are the most trending topics in this area. The TreeMap's bigger rectangles indicate these keywords, as well as their proportional size and the number of articles in which they appear. Figure 14 depicts the produced keyword TreeMap.

Fig. 14. TreeMap of keywords

Figure 14 shows that decision-making has the highest usage rate of 20% (corresponding to 20% of the total keywords), as shown by the blue rectangle. Sensitivity analysis comes next with 7% and then fuzzy sets with 4%.

4.2.4. Keyword co-occurrence analysis

A keyword is a term or phrase that is used to identify an article. The presence of a keyword in the article determines the prevalence of any phrase. The frequency of a keyword within an article is indicative of its significance. In order to underscore the consequential aspects of dealing with keywords and exploring the knowledge base of a study, the analytical tool VOSviewer was utilized. Through an examination of the article's indexed keywords, a total of 859 keywords were identified.

Figure 15 visually represents the outcome of the analysis conducted using the VOSviewer application. To focus on more relevant and significant keywords, the threshold setting within the application was adjusted to 3. Consequently, this refinement led to the evaluation of 69 keywords for in-depth investigation.

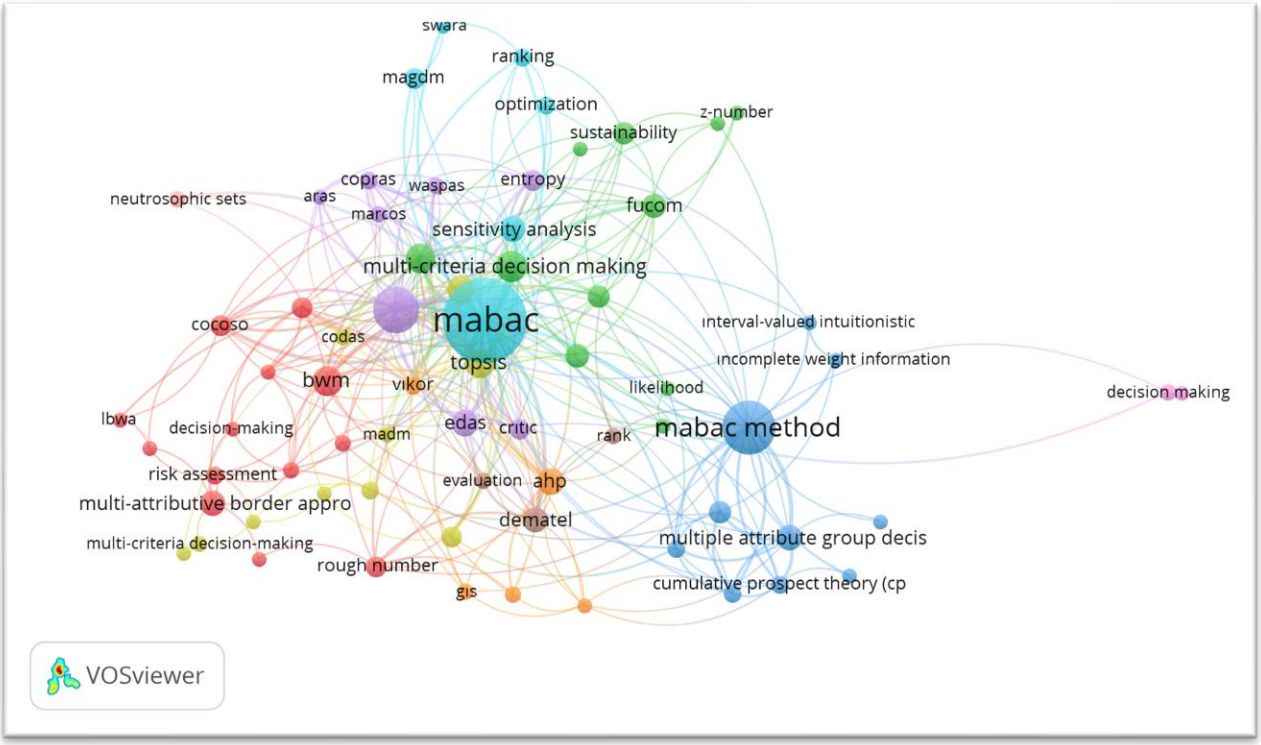

Fig. 15. Co-occurrence keywords

A different set of keywords is created with each color. In Figure 14, each circle represents the presence of a certain term and the sub-domain of MABAC method network topic. A circle of similar color represents the distribution in a comparison region. The largest cluster according to the number of items is named "MABAC". This cluster contains keywords such as optimization, ranking, SWARA. The second largest cluster is named "MABAC method". It contains keywords such as combined weights, green supplier selection, cumulative prospect theory. The third large cluster is named "MCDM". It consists of keywords such as COPRAS, CRITIC, EDAS, ENTROPY, MARCOS and WASPAS.

Using VOSviewer software, "overlay visualization" were colored differently according to the year of publication and the time intervals in which they appeared in the literature were determined. In our case, for newly introduced terminology, the average (yellow) publication year is 2022. The colors of the items were determined according to the time elapsed since their publication. The period from 2019 to 2022 (Blue-Green-Yellow Colour) is shown in Figure 16. While keywords such as DEMATEL, CODAS, EDAS, which were used before, are keywords that have been intensively studied in the 2019-2021 range, it can be said that keywords such as optimization, CoCoSo, uncertainty have also been used in the literature recently.

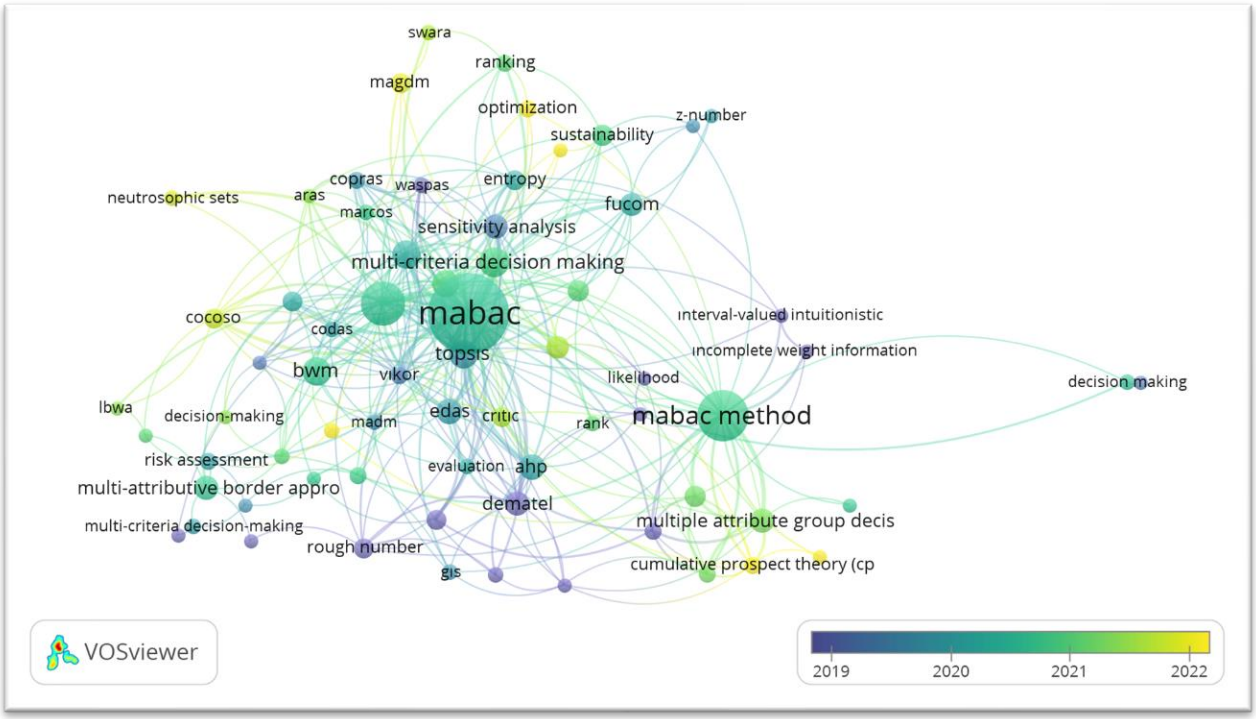

Fig. 16. Overlay network of keyword

5. Discussions

The growth in scientific output on topics related to MCDM is enormous. There are relatively few studies analyzing bibliometric data of research papers in different fields. A search of the Scopus database was performed. Initially, 264 English articles produced using the MABAC method were retrieved within the required time frame.

The average age of articles was 2.33 years, and the average citation per document was 31.23. 18 out of 622 writers wrote as a single author. International co-authorship accounts for 28.41% of overall article co-authorship. The top journal, according to the Sankey graph, is "Symmetry," the leading work, according to the author parameter, is "Pamučar D.", and the keyword is "MABAC."

This is one of the first bibliometric studies that employ MABAC method to determine the most productive authors, reference books, organizations, countries, and academic subjects. The Scopus database was combed through for articles. Since the majority of the articles are open access, a large number of authors emerge as the topic progresses and contributions are rapidly and widely disseminated. According to previous research, China, India and Serbia are the countries that produce the most academic work in this field. The most productive document is "The selection of transport and handling resources in logistics centres using Multi-Attributive Border Approximation area Comparison (MABAC)" by Pamučar and Ćirović [2] published in Expert Systems with Applications. The most cited journal is "Expert Systems with Applications". According to our research, the organization that has conducted the most studies on the subject or the organization to which the authors are affiliated is "University of Defence in Belgrade", which is the organization that has published the most publications. "Pamučar D." is the most published and also the most cited author.

Results of the study shows that a different set of keywords was used with each color for keywords. "MABAC", "MABAC method" and "MCDM" were identified as the most frequently used keywords. For further details on the three biggest clusters based on the number of components: Cluster 1 consists of keywords such as optimization, ranking and SWARA. Keywords in Cluster 2 include

combined weights, green supplier selection, and cumulative prospect theory. Cluster 3 includes terms like COPRAS, CRITIC, and EDAS.

Scientific maps were utilized in this study to present a complete overview of the key trends and findings in research related to the MABAC approach, employing conceptual constructs that define the primary themes, subjects, and intellectual constructs that classify how an author's work is impacted. The factor analysis results in two clusters of keywords connected to the MABAC approach in terms of factor loadings. In the first cluster with high factor loadings: CoCoSo, EDAS, TOPSIS, MAIRCA, MABAC, CRITIC, neutrosophic sets, rank, uncertainty, risk assessment, supplier selection, mabac method, multi-attributive border approximation area comparison MCDM. Multi-attribute group decision-making, combined weights, ENTROPY method keywords were also collected in the other cluster. Considering the keywords, the niche themes were MCDM and BWM. Emerging themes were z-number and regret theory. The basic (developing) themes were MABAC, fuzzy logic and SWARA. Motor (advanced) themes were rough numbers and extended MABAC. In the first quarter of 2019, the second quarter of 2021, and the third quarter of 2022, "decision making" was the most trending topic. "Sensitivity analysis" was a hot subject in the first quarters of 2019, 2021, and 2022. Currently, "multi-criteria decision-making" and "comparison methods" are the most trending topics in this field.

This is the first bibliometric study on MABAC method literature published between 2015 and 2023, to the best of the authors' knowledge. This study focuses on papers indexed in the Scopus database that are connected to the MABAC method used in MCDM investigations.

6. Conclusions

Using data from the Scopus database, this study analyzed and evaluated international scientific achievements in MABAC method research. The current top researchers were selected, and regional distributions and publications were mapped. In terms of the number of things created, China is the most productive country. In the bibliometric evaluation of MABAC approach used in MCDM papers, "Pamučar D." is the most prolific author. "Expert Systems with Applications" is the most referenced journal for sensitivity analysis papers. The authors' most essential keywords are MABAC, MABAC technique, and MCDM. BWM and TOPSIS are two MCDM models that are frequently used in conjunction with MABAC method.

By thoroughly summarizing research through MABAC method, it is anticipated that the door will be opened for further study areas and perspectives in the constantly expanding field of MCDM. The following administrative consequences for future work may be delineated: (1) Critical information is added to the evaluation of MABAC method by this research, which identifies the most influential sources, authors, relationships, nations, and studies in the available literature. The choice of which articles to cite, which papers to emphasize, and which studies have the most impact on MABAC method can be made by practitioners and researchers. (2) A comprehensive overview of historical and current research, as well as future research directions for MABAC method in MCDM domain, is provided by this bibliometric analysis. (3) Insight into the current state of research on MABAC method is afforded by results of this study. Additionally, scholars are provided with a thorough understanding of the MABAC method as a reference. (4) Through the analysis of citations and co-citations, the identification of various research streams or areas that constitute their intellectual structure is enabled for researchers, allowing them to recognize themes and acquire knowledge. (6) Significant information for the examination of MABAC method in the field of MCDM, as well as the identification of areas of research that demand greater attention for theoretical and practical implications, may be furnished by this study as a paradigm for both academics and practitioners. Despite the Scopus

database being the primary focus of this research, alternatives such as Web of Science, Dimensions, PubMed, and the Cochrane Library are accessible. Additionally, the option to develop a mapping tool capable of providing more extensive data coverage is available.

Author Contributions

Conceptualization, G.D. and P.C.; Methodology, D.P; Software, G.D., P.C., S.Z., and D.P; Formal analysis, G.D. and P.C; Writing- original draft preparation - G.D., P.C., S.Z., and D.P, Writing- review and editing - G.D., P.C., S.Z., and D.P. All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding.

Data availability statement

The datasets used for the current study can be obtained from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical approval

This article does not involve any studies with human participants or animals performed by any of the authors.

References

[1] Koca, G., & Yıldırım, S. (2021). Bibliometric analysis of DEMATEL method. Decision Making: Applications in Management and Engineering, 4(1), 85–103. https://doi.org/10.31181/dmame2104085g

[2] Pamučar D., & Ćirović G. (2015). The Selection of Transport and Handling Resources in Logistics Centers Using Multi-Attributive Border Approximation Area Comparison (MABAC). Expert Systems with Applications, 42(6), 3016- 3028. https://doi.org/10.1016/j.eswa.2014.11.057

[3] Saaty, T. L. (1977). A scaling method for priorities in hierarchical structures. Journal of Mathematical Psychology, 15(3), 234–281. https://doi.org/10.1016/0022-2496(77)90033-5

[4] Saaty, R. (1987). The analytic hierarchy process-what it is and how it is used. Mathematical Modelling, 9(3-5), 161-176. https://doi.org/10.1016/0270-0255(87)90473-8

[5] Saaty, T. L. (2004). Decision making - the Analytic Hierarchy and Network Processes (AHP/ANP). Journal of Systems Science and Systems Engineering, 13(1), 1-35. https://doi.org/10.1007/s11518-006-0151-5

[6] Fontela, E., & Gabus, A. (1974). DEMATEL, Innovative Methods. Report No. 2, Structural analysis of the world problematique. Battelle Geneva Research Institute (Battelle Memorial Institute).

[7] Pamučar, D., Stević, Ž., & Sremac, S. (2018). A new model for determining weight coefficients of criteria in MCDM models: Full Consistency Method (FUCOM). Symmetry, 10(9), 393. https://doi.org/10.3390/sym10090393

[8] Rezaei, J. (2015). Best-worst multi-criteria decision-making method. Omega, 53, 49-57. https://doi.org/10.1016/j.omega.2014.11.009

[9] Zakeri, S., Ecer, F., Konstantas, D., & Cheikhrouhou, N. (2021). The vital-immaterial-mediocre multicriteria decision-making method. Kybernetes. https://doi.org/10.1108/K-05-2021-0403

[10] Shannon, C. E. (1948). A mathematical theory of communication. Bell System Technical Journal, 27(3), 379–423. https://doi.org/10.1002/j.1538-7305.1948.tb01338.x

[11] Diakoulaki, D., Mavrotas, G., & Lefteris, P. (1995). Determining objective weights in multiple criteria problems: The CRITIC method. Computers & Operations Research, 22 (7), 763-770. https://doi.org/10.1016/0305-0548(94)00059-H

[12] Žižović, M., & Pamučar, D. (2019). New model for determining criteria weights: Level Based Weight Assessment (LBWA) model. Decision Making, 2(2). https://doi.org/10.31181/dmame1902102z

[13] Ghorabaee, M. K., Amiri, M., Zavadskas, E. K., Turskis, Z., & Antucheviciene, J. (2021). Determination of objective weights using a new method based on the removal effects of criteria (MEREC). Symmetry, 13(4), 525. https://doi.org/10.3390/sym13040525
[14] Zavadskas, E. K., & Podvezko, V. (2016). Integrated Determination of Objective Criteria weights in MCDM. International Journal of Information Technology and Decision Making, 15(02), 267–283. https://doi.org/10.1142/s0219622016500036
[15] Paramanik, A. R., Sarkar, S., & Sarkar, B. (2022). OSWMI: An objective-subjective weighted method for minimizing inconsistency in multi-criteria decision-making. Computers & Industrial Engineering, 169, 108138. https://doi.org/10.1016/j.cie.2022.108138
[16] Demir, G., Chatterjee, P., & Pamučar, D. (2024). Sensitivity Analysis in Multi-Criteria Decision Making: A State-of-the-Art Research Perspective Using Bibliometric Analysis. Expert Systems with Applications, 237, 121660. https://doi.org/10.1016/j.eswa.2023.121660
[17] Keeney, R.L. & Raiffa, H. (1976). Decisions with multiple objectives: preferences and value trade-offs. John Wiley & Sons, New York.
[18] Hwang, C.L. & Yoon, K. (1981). Multiple Attribute Decision Making: Methods and Applications. Springer-Verlag, New York. http://dx.doi.org/10.1007/978-3-642-48318-9
[19] Zavadskas, E.K., & Turskis, Z. (2010). A new additive ratio assessment (ARAS) method in multicriteria decision-making. Technological and Economic Development of Economy. 16(2), 159-172. https://doi.org/10.3846/tede.2010.10
[20] Stević, Ž., Pamučar, D., Puška, A., & Chatterjee, P. (2020). Sustainable supplier selection in healthcare industries using a new MCDM method: Measurement of alternatives and ranking according to COmpromise solution (MARCOS). Computers & industrial engineering, 140, 106231. https://doi.org/10.1016/j.cie.2019.106231
[21] Puška, A., Stević, Ž., & Pamučar, D. (2022). Evaluation and selection of healthcare waste incinerators using extended sustainability criteria and multi-criteria analysis methods. *Environment, Development and Sustainability*, 24(9), 11195-11225. https://doi.org/10.1007/s10668-021-01902-2
[22] Zavadskas, E. K., Turskis, Z., Antucheviciene, J., & Zakarevicius, A. (2012). Optimization of Weighted Aggregated Sum Product Assessment. Elektronika Ir Elektrotechnika, 122(6), 3-6. https://doi.org/10.5755/j01.eee.122.6.1810
[23] Pamučar, D., Vasin, L., & Lukovac, L. (2014, October). Selection of railway level crossings for investing in security equipment using hybrid DEMATEL-MARICA model. In XVI international scientific-expert conference on railway, railcon (pp. 89-92). https://doi.org/10.13140/2.1.2707.6807
[24] Gomes, L. F. A. M. & Lima M. M. P. P. (1992). From Modeling Individual Preferences to Multicriteria Ranking of Discrete Alternatives: A Look at Prospect Theory and The Additive Difference Model. Foundations of Computing and Decision Sciences, 17(3), 171-184. https://doi.org/10.2478/v10209-011-0001-1
[25] Yazdani, M., Zarate, P., Kazimieras Zavadskas, E. & Turskis, Z. (2019). A combined compromise solution (CoCoSo) method for multi-criteria decision-making problems. Management Decision, 57(9). https://doi.org/10.1108/MD-05-2017-0458
[26] Mishra, A. R., Rani, P., Saha, A., Hezam, I. M., Marinović, M. & Pandey, K. (2022). Assessing the Adaptation of Internet of Things (IoT) Barriers for Smart Cities' Waste Management Using Fermatean Fuzzy Combined Compromise Solution Approach. IEEE Access, 10. https://doi.org/10.1109/ACCESS.2022.3164096
[27] Zaliluddin, D. (2023). Bibliometric Analysis of Accuracy of Multi-Criteria Decision Making (MCDM) of Assistance Recipients with Fuzzy Logic Algorithm. West Science Interdisciplinary Studies, 1(07), 329-339. https://doi.org/10.58812/wsis.v1i07.82
[28] Vatankhah, S., Darvishmotevali, M., Rahimi, R., Jamali, S. M., & Ale Ebrahim, N. (2023). MCDM in travel and tourism research since 1997: A bibliometric approach. International Journal of Contemporary Hospitality Management. http://dx.doi.org/10.2139/ssrn.4324990
[29] Liao, H., Yang, S., Kazimieras Zavadskas, E., & Škare, M. (2023). An overview of fuzzy multi-criteria decision-making methods in hospitality and tourism industries: bibliometrics, methodologies, applications and future directions. Economic Research-Ekonomska Istraživanja, 36(3), 2150871. https://doi.org/10.1080/1331677X.2022.2150871
[30] Herawan, T., Arsyad, S., Widodo, W. I., Adiyanti, A. S., Damiasih, D., Ashartono, R., & Sâri, E. N. (2023). A Decade Bibliometric Analysis of Decision Making in Tourism and Hospitality. In International Conference on Computational Science and Its Applications (pp. 17-36). Cham: Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-37126-4_2
[31] Nirmal, D. D., Nageswara Reddy, K., & Singh, S. K. (2023). Application of fuzzy methods in green and sustainable supply chains: critical insights from a systematic review and bibliometric analysis. Benchmarking: An International Journal. https://doi.org/10.1108/BIJ-09-2022-0563

[32] Sohail, S. S., Javed, Z., Nadeem, M., Anwer, F., Farhat, F., Hussain, A., Himeur, Y. & Madsen, D. Ø. (2023). Multi-criteria decision making-based waste management: A bibliometric analysis. Heliyon 9. e21261. https://doi.org/10.1016/j.heliyon.2023.e21261

[33] Xu, D., & Xu, Z. (2023). Bibliometric analysis of decision-making in healthcare management from 1998 to 2021. International Journal of Healthcare Management, 16(4), 623-637. https://doi.org/10.1080/20479700.2022.2134641

[34] Ayan, B. & Abacıoğlu, S. (2022). Bibliometric analysis of the MCDM methods in the last decade: WASPAS, MABAC, EDAS, CODAS, CoCoSo and MARCOS. International Journal of Business and Economic Studies, 4(2), 65-85. https://doi.org/10.54821/uiecd.1183443

[35] Ferreira, F. A., & Santos, S. P. (2021). Two decades on the MACBETH approach: a bibliometric analysis. Annals of Operations Research, 296(1), 901–925. https://doi.org/10.1007/s10479-018-3083-9

[36] 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. https://doi.org/10.1016/j.jclepro.2019.07.016

[37] 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

[38] Martín-Martín, A., Orduna-Malea, E., Thelwall, M., & López-Cózar, E. D. (2018). Google Scholar, Web of Science, and Scopus: A systematic comparison of citations in 252 subject categories. Journal of Informetrics, 12(4), 1160-1177. https://doi.org/10.1016/j.joi.2018.09.002

[39] Aria, M., & Cuccurullo, C. (2017). Bibliometrix: An R-tool for comprehensive science mapping analysis. Journal of Informetrics, 11(4), 959-975. https://doi.org/10.1016/j.joi.2017.08.007

[40] Van Eck, N. J., & Waltman, L. (2017). Citation-based clustering of publications using CitNetExplorer and VOSviewer. Scientometrics, 111(2), 1053-1070. https://doi.org/10.1007/s11192-017-2300-7

[41] Peng, X. & Yang, Y. (2016). Pythagorean Fuzzy Choquet Integral Based MABAC Method for Multiple Attribute Group Decision Making. International Journal of Intelligent Systems, 31(10), 989-1020. https://doi.org/10.1002/int.21814

[42] Gigović, L., Pamučar, D., Božanić, D., & Ljubojević, S. (2017). Application of the GIS-DANP-MABAC multi-criteria model for selecting the location of wind farms: A case study of Vojvodina, Serbia. Renewable Energy, 103, 501–521. https://doi.org/10.1016/j.renene.2016.11.057

[43] Pamučar, D., Petrović, I., & Ćirović, G. (2018). Modification of the Best–Worst and MABAC methods: A novel approach based on interval-valued fuzzy-rough numbers. Expert Systems With Applications, 91, 89–106. https://doi.org/10.1016/j.eswa.2017.08.042

[44] Peng, X., & Dai, J. (2016). Approaches to single-valued neutrosophic MADM based on MABAC, TOPSIS and new similarity measure with score function. Neural Computing and Applications, 29(10), 939–954. https://doi.org/10.1007/s00521-016-2607-y

[45] Pamučar, D., Mihajlović, M., Obradović, R., & Atanasković, P. (2017). Novel approach to group multi-criteria decision making based on interval rough numbers: Hybrid DEMATEL-ANP-MAIRCA model. Expert Systems With Applications, 88, 58–80. https://doi.org/10.1016/j.eswa.2017.06.037

[46] Xue, Y., You, J., Liu, X., & Liu, H. (2016). An interval-valued intuitionistic fuzzy MABAC approach for material selection with incomplete weight information. Applied Soft Computing, 38, 703–713. https://doi.org/10.1016/j.asoc.2015.10.010

[47] Şennaroğlu, B., & Celebi, G. V. (2018). A military airport location selection by AHP integrated PROMETHEE and VIKOR methods. Transportation Research Part D: Transport and Environment, 59, 160–173. https://doi.org/10.1016/j.trd.2017.12.022

[48] Gupta, S., Soni, U., & Kumar, G. (2019). Green supplier selection using multi-criterion decision making under fuzzy environment: A case study in automotive industry. Computers & Industrial Engineering, 136, 663–680. https://doi.org/10.1016/j.cie.2019.07.038