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Procedia Computer Science 221 (2023) 410–417

Procedia Computer Science

www.elsevier.com/locate/procedia

10th International Conference on Information Technology and Quantitative Management

BIBLIOMETRIC STUDIES OF RANKING OF ALTERNATIVES THROUGH FUNCTIONAL MAPPING OF CRITERION SUB-INTERVALS INTO A SINGLE INTERVAL (RAFSI) METHOD

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Abstract

This article aims to present a bibliographic survey of the Ranking *of* Alternatives through Functional mapping of criterion sub-intervals into a Single Interval (RAFSI) method, besides following steps and equations for its application. Although it is a recent method, with its proposal by Žižović in 2020, it has already been applying in several areas. The method eliminates rank reversal, which arise when unexpected changes to the classification of alternatives occur when any non-optimal alternative is added to or deleted from the existing set of alternatives. In addition to these points observed, the work clearly and objectively demonstrates information about the most relevant authors, countries where the method is more used, the areas of application, citations as well as analysis of keyword clusters

Keywords: RAFSI, Bibliographic Review, Operations Research, Multicriteria Decision Support (MDS).

1. Introduction

Decision-making is integrated with human activity, characterized by analyzing a set of actions in search of a favorable solution to a given problem [1-3]. In many cases, with the expansion of the number of variables linked to a decision-making process, multiple decision-makers and different perspectives, there is also an increase in the degree of complexity, leading to the request for integration of mathematical and computational models to support the decision-making process [4].

10.1016/j.procs.2023.07.054

At this juncture, Operations Research (OR) uses mathematics, statistics and computing to assist in solving real problems, focusing on making the best decisions in the most diverse areas of scientific and human activity, and seeking to optimize and improve their performance [5, 6]. Inside the OR is framed the Multi-Criteria Decision Aid (MCDA)

MCDA methods allow organization systems to structure the decision-making process, considering various aspects of evaluation, such as technical, socioeconomic and environmental issues at the operational, strategic [7] and tactical levels in favor of a direction aligned with the objectives in a given problematic situation [8]. In addition to technical issues, they consider value judgments to evaluate alternatives to solve real problems, presenting high multidisciplinary [9].

Furthermore, MCDA methods also present techniques that allow the structuring and understanding of a problem in a complicated environment [10] and have already been employed to support the decision-making process in several recent complex problems [11-25], considering risk and uncertainty, helping to clarify favorable solutions to problems of varied nature through an interactive and transparent process [26,27].

The methods present in the MCDA seek to establish preferences between alternatives under the analysis of criteria that often conflict with each other [28]. Preferences translates into the hierarchization of one criterion over another Thus, for each criterion, the decision maker has a function in mind [29]. The three main types of questions addressed in models belonging to the MCDA are: Choice, exposing the most favorable alternative in a global context; Order, establishing order from the most favorable to the least favorable alternatives with a form of the solution; and Classification, by housing the alternatives in dominance classes [30].

One of the most important problems that occur in most AMD methods with predetermined preferences is the lack of resistance to rank reversal problems. If unexpected changes in the classification of alternatives occur when any non-optimal alternative is added or deleted from the existing set of alternatives, this indicates serious mathematical problems in the applied AMD method [31].

A new AMD method, called Ranking of Alternatives through Functional mapping of criterion sub-intervals into a Single Interval (RAFSI) eliminates classification reversion problems [31].

This article presents a bibliographic survey of the method through the Scopus and Web of Science databases, where 12 articles were found, of these, 9 were classified as hybrids and 1 article of the RAFSI method proposal, and 2 articles with new approaches from the original method.

2. Literature Review

In this session we present the articles that are hybrid with other methods, the article of the proposal of the RAFSI method and new approaches from the original method, as well as a broader review using Bibliometrix with VOSviewer. When performing a search in the Scopus and Web of Science databases, 9 hybrid articles were found that use RAFSI with other methods, as shown in Table 1.

Table 1 – Hybrid articles found in the literature

Title	Type	Method	Year	Base
Development of a Multi-Criteria Model for Sustainable Reorganization of a Healthcare System in an Emergency Situation Caused by the COVID-19 Pandemic [32]	HYBRID	FUZZY - LBWA–MACBETH–RAFSI	2020	Scopus
D numbers – FUCOM – FUZZY RAFSI model for selecting the group of construction machines for enabling mobility [33]	HYBRID	D numbers - FUCOM – FUZZY- RAFSI	2021	Scopus
A Flight Base Selection for Flight Academy Using a Rough MACBETH and RAFSI Based Decision-Making Analysis [34]	HYBRID	Rough MACBETH-RAFSI	2021	Scopus
Floating photovoltaic site selection using Fuzzy Rough numbers based LAAW and RAFSI model [35]	HYBRID	LAAW - RAFSI	2022	Scopus
A New Hybrid Fuzzy Multi-Criteria Decision Methodology for Prioritizing the Antivirus Mask Over COVID-19 Pandemic [36]	HYBRID	FUZZY-BWM-RAFSI	2022	Web of Science
An integrated Fucom-Rafsi model for assessing the potential of a new gateway port in Libya for some African landlocked countries [37]	HYBRID	FUCOM-RAFSI	2022	Scopus
Personal Mobility in Metaverse with Autonomous Vehicles Using Q-Rung Orthopair Fuzzy Sets Based OPA-RAFSI Model [38]	HYBRID	OPA (Ordinal PriorityApproach) - RAFSI	2022	Scopus
A Novel Approach of Ranking of Alternatives Through Functional Mapping of Criterion Sub-Intervals into a Single Interval (RAFSI) Method under a Fermatean Environment [39]	HYBRID	FUZZY RAFSI	2022	Scopus
Sustainable E-scooter parking operation in urban areas using fuzzy Dombi based RAFSI model [40]	HYBRID	FUZZY Dombi, RAFSI	2023	Scopus

In addition to the research to verify the hybrid methods, the article of the proposal of the RAFSI method and new approaches from the original method were also verified, as indicated in Table 2, where 3 articles were found.

Table 2 – Proposal of the RAFSI method and its new approaches

Title	Type	Method	Year	Base
Eliminating Rank Reversal Problem Using a New Multi-Attribute Model-The RAFSI Method [31]	Proposal for the RAFSI method	RAFSI	2020	Scopus
Monitored air pollutants from waste-to-energy facilities in China: Human health risk, and buffer distance assessment [41]	Extension	Analysis of uncertainty and sensitivity using Monte Carlo simulation and application of the RAFSI method and comparison of results with the Simple Additive Weighting (SAW) method	2022	Scopus
A comparative assessment of multicriteria parametric optimization methods for plasma arc cutting processes [42]	Extension	Use of the MEREC and CRITIC methods to survey the weights of the criteria for the use of RAFSI.	2023	Scopus

In the Scopus database when using the following search filter on 02/05/2023: TITLE-ABS-KEY (RASFI), 13 articles were found.

In the Web of Science database using the following search filter on 02/05/2023: Topics (RASFI), 10 articles were found.

After 2 articles that were out of scope were removed and after 8 more that were in redundancy between the two bases were removed. After 13 documents, they were analyzed through the Bibliometrix package.

Table 3 shows the application of RAFSI in the annual scientific production from 2020 to 05/02/2023 and the average number of citations per year until 05/02/2023.

Table 3 – Annual scientific production – papers and average citations of articles per year

Year	Annual scientific production – papers	Average citations of articles per year
2020	3	5,42
2021	2	10,83
2022	5	3,3
2023	3	1

As you can see there is a growth of publications in 2022 compared to 2021. Considering that 2023 is only in May, it may be that this growth continues this year. Citations are declining, which may be a reflection of the increase in publications.

The publications by area are relevant because they demonstrate the importance of applying the method, since it is being applied in several areas to solve various problems. It is observed that the areas of Engineering, Energy, Environmental Science, Business, Management and Accounting, Computer Science, Decision Science, Mathematics and Social Science are the areas that concentrate about 89% of the publications. Table 4 shows the number of articles published per area, in which RAFSI was applied.

Table 4 – Number of articles published per area, in which RAFSI was applied

Areas	Number of articles
Engineering	6
Energy	6
Environmental Science	3
Business, Management and Accounting	2
Computer science	2
Mathematics	2
Social Science	2
Earth and Planetary Sciences	1
Materials Science	1

In addition to observing the areas in which the method is being applied, another relevant factor in the bibliographic review is to verify which were the most relevant sources (*Journals*). Table 5 shows 5 Journals that obtained the largest publications in quantity on the subject.

Table 5 – Journals that obtained the largest publications in quantity on the subject

Journal	Number of articles
Mathematics	2
Applied Energy	1
Atmospheric Pollution Research	1
Decision Analytics Journal	1
Facta Universitatis Series Mechanical Engineering	1

In addition to the sources, analyzing the authors indexes demonstrates that the researchers involved in the method are being cited and published significantly. The H index is defined as the number of articles with a number of citations greater than or equal to H [43]. Table 6 shows the H index of the 5 most relevant authors of the bibliographic review, which indicates that the most relevant is Muhammet Deveci, with an H index of 3, that is, he obtained 3 publications being cited at least 3 times.

Table 6 – H index of the 5 most relevant authors

Author	H Index
DEVECI H.	3
PAMUCAR D.	3
GOKASAR I.	2
PAMUčAR D.	2
ŽIŽOVIĆ M.	2

In addition to the H index, the G index, presents a differentiated approach for the evaluation of the authors, since it considers the largest number, in such a way that the top G articles received (together) at least the g^2 citations, thus, when evaluating Dragan Pamučar index, it is understood that the 6 main publications of the author were cited at least 36 times or 6^2. Table 7 shows G index of the 5 most relevant authors and the number of publications of the method by authors.

Table 7 – G index of the 5 most relevant authors and the number of publications of the method by authors.

Author	G Index	Articles
PAMUCAR D.	6	7
DEVECI H.	5	5
GOKASAR I.	3	3
PAMUčAR D.	2	2
ŽIŽOVIĆ M.	2	2

Analyzing by Country/territory, it was identified that more than 60% of the publications were developed in Serbia, Turkey, United Kingdom, China, India and Taiwan. Therefore, it is concluded that much of the research where RAFSI is applied, are developed in Europe and the East. There is an opportunity for applications of the method in the West, especially in South America, where no publication has been identified, as shown in Table 8.

Table 8 – G index of the 5 most relevant authors and the number of publications of the method by authors.

Country/territory	Number of articles	Accumulated percentage
SERBIA	6	21%
TURKEY	3	31%
UNITED KINGDON	3	41%
CHINA	2	48%
INDIA	2	55%
TAIWAN	2	62%
UNDEFINED	2	69%
AUSTRÁLIA	1	72%
AUSTRIA	1	76%
GERMANY	1	79%
INDONÉSIA	1	83%
LIBYAN ARAB JAMAHIRIYA	1	86%
PHILIPPINES	1	90%
POLAND	1	93%
UNITED STATES	1	97%
VIETNAM	1	100%

The VOSviewer software was used to analyze keyword clusters and the authoring network. This tool is very useful for creating maps, visualizing and exploring data [44]. Increasing publication rates and fragmented research streams make the use of bibliometrics essential for scientific mapping [45 - 48].

Analyzing the clusters of keywords, considering 3 as the minimum number of occurrences, it was found that only 4 out of 119 keywords reached this limit. The keyword "decision making" has the highest number of occurrences (o = 5) and the highest total bond strength (s = 9), followed by "multicriterion decision making", "multi criteria decision-making" and "*multicriterion decision-making",* all with equal number of occurrences and total bond strength (o = 3, s = 9).

3. RAFSI method

It is assumed that decision-makers have to classify alternatives based on n criteria, already having the weights of the criteria and that they are meeting the following condition that the sum of the weights be equal to 1. ($\sum_{j=1}^{n} w_j = 1$). The criteria can be of the benefit type (max) or of the cost type (min)[31].

The RAFSI method has the following steps:

Step 1: Set ideal and anti-ideal values. For each criterion, the decision-maker defines two values, for the ideal value of the criterion a_{Ij} and for the anti-ideal value of the criterion. For a_{Nj}> benefit type criteria a_{Ij} and for a_{Nj}< cost type criteria a_{Nj} .a_{Ij}

Step 2: Mapping the elements of the initial decision matrix into ranges of the criteria. In order to make all the criteria of the initial decision matrix equal or to transfer them to the range criteria [n_1, n_{2k}], a sequence of numbers is formed from the range k in the manner in which k -1 points are inserted between the highest and lowest values of the criteria range. It is suggested that the ideal value is at least six times better than the anti-ideal (unacceptable value), or = 1 and = 6. However, the decision-maker can use other preferred values such as = 1 and = 9.

The function, $f_{s\,(X)}$ Equation (1), is used to insert the subintervals in the range of criteria [n_1, n_{2k}], where $n_{2k}$and $n_1$represent the relation that shows to what extent the ideal value is preferred over the anti-ideal value, and where a_{Ij} and a_{Nj} represent ideal and anti-ideal values of the criteria Cj, respectively.

$$f_{s\,(X)} = \frac{n_{2k}-n_1}{a_{Ij}-a_{Nj}}x - \frac{a_{Ij}\cdot n_1 - a_{Nj}\cdot n_{2k}}{a_{Ij}-a_{Nj}} \quad (1)$$

The function $f_{s\,(X)}$ can represent a function that maps a part of a range, but it can also map a criterion range to the corresponding numeric range. Therefore, the numbers a_{Ij} e a_{Nj} and can represent: (1) values from within the criterion range or (2) end points from the criterion range.

After applying the function $f_{s\,(X)}$ to each criterion value, the standardized decision matrix S = [sij]m×n is obtained

Step 3: Calculation of the arithmetic mean, Equation (2), and Harmonic mean, Equation (3).

$$A = \frac{n_{1+}\, n_{2k}}{2} \quad (2)$$

$$H = \frac{2}{\frac{1}{n_1}+\frac{1}{n_{2k}}} \quad (3)$$

Step 4: Normalization of the standardized decision matrix S = [sij]m×n getting $\hat{S} = [\,\widehat{S}_{IJ}]\; m\times n$. For criteria can of the benefit type if Equation (4) is used and for criteria can of the cost type if Equation (5) is used:

$$\widehat{S}_{IJ} = \frac{S_{IJ}}{2A} \quad (4)$$

$$\widehat{S}_{IJ} = \frac{H}{2S_{IJ}} \quad (5)$$

Step 5: The functions of the criteria of the alternatives (V(Ai)) are calculated according to Equation (6) below. The alternatives are then sorted according to the descending order of the calculated values [V(Ai)].

$$V(Ai) = w1\,\widehat{S}_{i1} + w2\,\widehat{S}_{i2} + : : : + wn\;\widehat{S}_{in} \quad (6)$$

4. Conclusion

The present work presented the bibliographic review in an easy and detailed way of the method that eliminates problems of classification reversal, Functional Mapping of Subinterval Criteria in a Single Interval Method (RAFSI).

The research was conducted in the Scopus and Web of Science database on May 2, 2023 and because it is a recent method, it resulted in only 13 documents found. With the use of the computational tool Bibliometrix, and the VOSviewer software, all the pertinent analyses of the research were carried out, as well as the H and G indexes, the publications by area, countries with more publications, the citations, the Journals and the most relevant authors. The present work also demonstrates in detail which are the hybrid articles and other articles found to date. Thus, it is considered that the bibliographic research of the RAFSI method presents relevance and demonstrates the potential of the model applied in several countries, by various authors and in areas with different problems.

There is a gap for the study of this new method in Latin America, since no documents have been identified.

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