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Review

A Comprehensive Review of the Novel Weighting Methods for Multi-Criteria Decision-Making

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Abstract: In the realm of multi-criteria decision-making (MCDM) problems, the selection of a weighting method holds a critical role. Researchers from diverse fields have consistently employed MCDM techniques, utilizing both traditional and novel methods to enhance the discipline. Acknowledging the significance of staying abreast of such methodological developments, this study endeavors to contribute to the field through a comprehensive review of several novel weighting-based methods: CILOS, IDOCRIW, FUCOM, LBWA, SAPEVO-M, and MEREC. Each method is scrutinized in terms of its characteristics and steps while also drawing upon publications extracted from the Web of Science (WoS) and Scopus databases. Through bibliometric and content analyses, this study delves into the trend, research components (sources, authors, countries, and affiliations), application areas, fuzzy implementations, hybrid studies (use of other weighting and/or ranking methods), and application tools for these methods. The findings of this review offer an insightful portrayal of the applications of each novel weighting method, thereby contributing valuable knowledge for researchers and practitioners within the field of MCDM.

Keywords: MCDM; weighting methods; CILOS; IDOCRIW; FUCOM; LBWA; SAPEVO-M; MEREC

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1. Introduction

The researcher faces a growing challenge due to the volume of research published monthly by thousands of academic publishing platforms. Following up on the results of research and methods developed and integrated with other tools has become a task that consumes much of the research work. According to the theory of bounded rationality, the rationality of a researcher is limited by the available knowledge, the cognitive limitations of the individual mind, and the availability of decision-making (DM) time. In this sense, the systematized work of literature review through bibliometric analysis has contributed as a starting point for many researchers.

In the context of the present research, it can be asserted that DM is a fundamental aspect of human activities as it is present in every aspect of life. This involves evaluating individual decision options based on the decision-makers' (DMs) preferences, experience, and other relevant data. In both personal and organizational settings, DMs are faced with a portfolio of simple and complex decisions, varying in their potential impact and consequences. Resolving real-life problems often requires the consideration of multiple competing perspectives to arrive at a reasonable decision. A decision can be formally defined as a choice made based on available information or a method of action intended to address a specific decision problem. Whether in an organizational or household environment, DMs are constantly confronted with multiple paths and limited resources [1].

To enhance the DM process, it is essential to have a framework that can distinguish between options and establish a hierarchy of choices. This framework involves identifying and selecting relevant factors, also known as criteria, which can be used to differentiate between alternatives. Multi-criteria decision-making (MCDM) comprises three main components: several different criteria, a set of alternatives, and a comparison process between them [2]. MCDM techniques involve evaluating and selecting the best alternative(s) among a set of alternatives, which are assessed based on various criteria [3].

The influence of criteria weights on the outcome of the DM process is significant. The selection of a weighting method is a critical stage in MCDM problems as they help to determine the relative importance of each criterion and facilitate the DM process [4–6]. In addition, any MCDM problem requires the choice of the weighting methods because it directly influences the accuracy and reliability of the decision outcomes [6]. DMs should take into account a number of elements, including the decision problem's nature, the type of data, the measurement scale, the weighting of the criteria, and the interactions between the criteria [7]. The distinct characteristics of each weighting method generate varying weights attributed to the criteria [8,9], leading to different rankings that impact the entire order, not just the best alternative [10]. As a result, to ensure trust in the decision outcomes, it is recommended to choose multiple methods in determining the weights [8]. Additionally, it can be essential to conduct a comparative assessment of diverse approaches to identify the most fitting method for a specific problem [11].

The subject of determining weights for criteria is an area of investigation and academic discussion [12]. Weighting methods can be classified into three categories: subjective, objective, and combinative (integrated). Subjective methods require DMs to take responsibility for assigning weights to the criteria. In contrast, objective methods do not involve DMs in determining the relative importance of the criteria but instead use mathematical algorithms. The combinative approach involves a blend of both subjective and objective methods [6,13].

Several weighting methods have been proposed in the literature and have been utilized to address a range of MCDM issues. Examples of traditional weighting methods include AHP, MACBETH, DEMATEL, CRITIC, ENTROPY, and others [5]. In recent years, numerous weighing methods have been developed, including subjective, objective, and combined methods. However, only a limited number of papers have addressed the topic of weighing methods in MCDM, providing a comprehensive discussion of these methods [6]. Novel methods proposed in the last decade are as follows: BWM [14], CILOS [15], IDOCRIW [15], FUCOM [4], LBWA [5], SAPEVO-M [16], and MEREC [17]. There are a few review studies based on weighting methods [18], such as SWARA [19] and AHP, ANP, and BWM [6]. As noted, the selection of an appropriate weighting method for resolving a multi-criteria decision problem is a non-trivial undertaking, given the numerous extant techniques and novel approaches that have emerged in recent years. The aim of the present research, given the importance of criteria weighting methods and the scarcity of review studies in this area, is to conduct a comprehensive analysis of research on novel MCDM weighting methods and to provide valuable insights into the applications of each method. The study intends to contribute to the existing knowledge base within the field of MCDM by focusing on novel methods and offering useful information for both researchers and practitioners. The research aims to answer the following research questions:

RQ1. What is the trend of the publications over the years?
RQ2. What are the most productive and cited research components?
RQ3. Which publications have received more interest in terms of total citations?
RQ4. What are the application areas of the methods?
RQ5. What are the other methods (weighting and/or ranking) in the hybrid model applied publications?
RQ6. Have fuzzy studies on methods been applied?
RQ7. Have platforms (R, Python, or web-based) been developed for the implementation of the methods?

This article is structured as follows: Section 2 briefly describes the novel weighting methods. Section 3 describes the methodology to solve the proposed problem. Section 4 presents the report of the results found. The main discussions and conclusion are summarized in Section 5.

2. Literature Review

2.1. CILOS and IDOCRIW

Zavadskas and Podvezko proposed the CILOS method by developing an idea put forward by Mirkin [20]. The CILOS method is an objective method that considers the loss of importance or impact of the remaining criteria when a criterion achieves the optimal maximum or minimum value. The smaller the relative loss of effect of a criterion, the greater the weight of the criterion. In contrast, if the relative loss of a criterion is large, the weight is small. In the ENTROPY method, the situation is the opposite. The advantage of the method is that CILOS eliminates the disadvantage of the ENTROPY method [15].

The steps of the CILOS method are as follows:

- Defining a decision matrix

$$A_{ij} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \tag{1}$$

- Transforming the minimized criteria

$$\bar{r}_{ij} = \frac{\overset{min}{i} r_{ij}}{r_{ij}} \tag{2}$$

The values of the maximized criteria require no transformation.

- Defining X as a result of transformation

$$X_j = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \tag{3}$$

- Calculating the highest values of each criterion in X

$$x_{ij} = \overset{max}{i} x_{ij} = x_{k_j j} \tag{4}$$

- Determining the square matrix A

$$A = \left|\left|a_{ij}\right|\right| \ \left(a_{ii} = x_i;\ a_{ij} = x_{k_j j}\right) \tag{5}$$

- Determining the matrix of the relative loss P

$$P = \left|\left|p_{ij}\right|\right| \tag{6}$$

$$p_{ij} = \frac{x_j - a_{ij}}{x_j} = \frac{a_{ii} - a_{ij}}{a_{ii}} \tag{7}$$

The diagonal elements of the matrix P are 0. The elements of p_{ij} in the matrix P show the relative loss of the jth criterion, if the ith criterion is selected to the best.

- Determining the matrix F

$$F = \begin{bmatrix} -\Sigma_{\mathrm{i}=1}^{m} p_{i1} & p_{12} & \cdots & p_{1m} \\ p_{21} & -\Sigma_{\mathrm{i}=1}^{m} p_{i1} & \cdots & p_{2m} \\ \vdots & \vdots & \cdots & \vdots \\ p_{m1} & p_{m2} & \cdots & -\Sigma_{\mathrm{i}=1}^{m} p_{im} \end{bmatrix} \tag{8}$$

- Solving the linear equation system

$$Fq^t = 0 \tag{9}$$

- Calculating criteria weights

$$q_i = \frac{x_i}{\sum x_i} \tag{10}$$

The IDOCRIW method is also an objective weighting method. It is a hybrid method that combines the weights obtained by the ENTROPY and CILOS methods. The advantages of one method are compensated for by the shortcomings of the other method. After the weights are obtained separately according to the ENTROPY and CILOS methods, a single weight is obtained from these weights. The weights obtained with IDOCRIW will show the variation of the criteria values (a characteristic of ENTROPY), but the significance of the criteria will decrease if there are higher losses compared to the other criteria [15].

The ENTROPY method involves the following steps:

- Defining the decision matrix

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (i = 1,\ 2,\ \ldots,\ m; j = 1,\ 2,\ \ldots,\ n) \tag{11}$$

- Normalizing the decision matrix

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \tag{12}$$

- Calculating the entropy values of criteria

$$E_j = -k \sum_{i=1}^{m} p_{ij} \ln(p_{ij}) \tag{13}$$

- Calculating the degrees of variation for each criterion

$$d_j = 1 - E_j \tag{14}$$

- Calculating criteria weights

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j} \tag{15}$$

The IDOCRIW method's calculation is given below:

$$\omega_j = \frac{q_j w_j}{\sum_{j=1}^{n} q_j w_j} \tag{16}$$

2.2. FUCOM

The FUCOM method is a comparison-based MCDM procedure applying the principles of pairwise comparison and deviation from maximum consistency [21]. It is a subjective-based method. FUCOM has several advantages over other methods, including the requirement of fewer pairwise comparisons ($n-1$), ensuring consistency in pairwise comparison of criteria, and accurately calculating weight coefficients for criteria, which enhances the validity of decision-making. The deviation from maximum consistency (DMC) of comparisons is used for validating the results of FUCOM.

The following are the steps of the FUCOM method:

- Ranking the criteria $(C_1,\ C_2, \ldots, C_n)$ according to their importance

  The higher the initial rank is, the more critical the criterion is to mineralization:

$$C_{J_1} > C_{J_2} > \ldots > C_{J_K} \tag{17}$$

- Comparing the ranked criteria

  The comparative priority ($\varphi_{\frac{k}{k+1}}$, $k = 1,\ 2, \ldots, n$, in which k represents the rank of the criteria) of the criteria is determined according to equation:

$$\varphi = \left\{ \varphi_{\frac{1}{2}} , \varphi_{\frac{2}{3}} , \ldots, \varphi_{\frac{k}{k+1}} \right\} \tag{18}$$

- Calculating the weight coefficients of the targeting criteria

  These values should meet the following conditions:
  The weight coefficients (w_k) are proportional to the comparative priorities $(\varphi_k\ )$:

$$\frac{w_k}{w_{k+1}} = \varphi_{\frac{k}{k+1}} \tag{19}$$

  The mathematical transitivity must be met among all the comparative priorities $(\varphi_k\ )$:

$$\varphi_{\frac{k}{k+1}}\ X\ \varphi_{\frac{k+1}{k+2}} = \varphi_{\frac{k}{k+2}} \tag{20}$$

- Solving optimization problem for calculating the optimal weights

$$Min\ X$$
$$s.t.$$

$$\left| \frac{w_{j(k)}}{w_{j(k+1)}} - \varphi_{\frac{k}{k+1}} \right| = X,\ \ \forall j \tag{21}$$

$$\left| \frac{w_{j(k)}}{w_{j(k+2)}} - \varphi_{\frac{k}{k+1}}\ X\ \varphi_{\frac{k+1}{k+2}} \right| = X,\ \ \forall j \tag{22}$$

$$\sum_{j=1}^{n} w_j = 1 \tag{23}$$

$$w_j \geq 0,\ \ \forall j$$

2.3. LBWA

The LBWA method is a subjective weighting method that is proposed to overcome difficulties in pairwise comparisons. It is based on (n-1) comparison, less than both BWM and AHP methods. The LBWA method's ability to preserve its simple structure regardless of the model's complexity is one of its key characteristics. In addition, simple mathematical apparatus is used to obtain the optimal values of weight coefficients, removing the inconsistent expert preferences that other subjective models permit such as BWM and AHP permit. Lastly, by allowing for additional coefficient corrections depending on decision makers' preferences, the LBWA model's elasticity coefficient enables sensitivity analysis of the MCDM model [5].

The LBWA method consists of the following steps:

- Determining the most important criterion

Within the set $S = \{C_1, C_2, \ldots, C_n\}$, the decision maker determines most important criterion.

- Grouping the criteria

The criteria are grouped according to their importance as follows:

Level 1: C_i, the most important criterion, is either of equal importance or at most two times more important than the criteria in this group (except exactly two times).

Level 2: C_i, the most important criterion, has at least two times and maximum three times more importance than the criteria in this group (except exactly three times).

Level 3: C_i, the most important criterion, is at least three times more important and at most four times more important than the criteria in this group (except exactly four times).

Level k: C_i, the most important criterion, is at least k times and at most (k + 1) times more important than the criteria in this group.

If the importance of the C_j, criterion is denoted by $s(C_j)$ then $S = S_1 \cup S_2 \cup \ldots \cup S_k$ is written and the following equation is obtained.

$$S_i = \{C_{i_1}, C_{i_2}, \ldots, C_{i_S}\} = \{C_j \in S : i \le s(C_j) < i + 1\} \tag{24}$$

- Assigning values to criteria

The criteria are compared according to their importance. An integer is assigned as "0" to the most important criterion and "1" to the second-degree criterion. That is, for C_i, which is the most important criterion, $I = 0$.

$$r = max\{|S_1|, |S_2|, \ldots, |S_k|\} \tag{25}$$

- Determining the elasticity coefficient r_0

$$r_0 > \mathrm{r} \tag{26}$$

- Defining the influence function of the criteria

$$f\left(C_{i_p}\right) = \frac{r_0}{i.r_0 + I_{i_p}} \tag{27}$$

$i =$ Level order, $I_{i_p} =$ The criteria range in the interval

- Calculating the optimum values of the weight coefficients of criteria

$$w_i = \frac{1}{f(C_1) + f(C_2) + \ldots + f(C_i) + \ldots + f(C_n)} \tag{28}$$

$w_i =$ weight of the most important criterion

Weights of other criteria

$$w_j = f(C_j).w_i \tag{29}$$

2.4. SAPEVO-M

The SAPEVO-M method is an evolution of the SAPEVO method, which was intended only for a mono-decision analysis. In addition to the new algorithm providing a multi-criteria analysis with multiple DMs, a process of standardization of matrices was integrated, through the correction of negative and null criteria weights, thus increasing the model consistency [16,22]. The method consists of two processes. Preliminary, the transformation of ordinal preference between criteria should be performed, expressed by a vector representing the criteria weights. The ordinal transformation of the preference between alternatives is then made within a given set of criteria, expressed by a matrix. A series of pairwise comparations between variables, whether criteria or alternatives within a given criterion, denote the individual preference information of each decision-maker.

The steps of the SAPEVO-M method are as follows:

- Given a set of alternatives and a set of criteria i, j, both defined by DMs, establishing criteria preferences, considering general elements (δ_{ij}), such that: $\delta_{ij} = 1 \leftrightarrow i \cong j$, $\delta_{ij} > 1 \leftrightarrow i > j$, $\delta_{ij} < 1 \leftrightarrow i < j$, where: $\cong$ is as important as, > is more important than, and < is less important than.
- Representing the criteria preferences of DMs by using a scale according to the relationship:

Relationship	**Scale**
<<1	−3
≤1	−2
<1	−1
1	0
>1	1
≥1	2

- Aggregating the preferences

This scale enables a transformation of the matrix $DM^k = [\delta_{ij}]$ into a column vector $[v_i]$ such that:

$$VDM_i^k = \sum_{i=1}^{n} \sum_{j=1}^{m} \delta_{i,j}, (\forall\, j = 1, \ldots, m; i = 1, \ldots, n.) \quad (30)$$

where k is the number of decision-makers participating in the evaluation process.

- Normalization

After obtaining the vector with the evaluation of DMs, the normalization of each vector will be carried out as follows:

$$V = \frac{a_{ij} - min_{a_{ij}}}{max_{a_{ij}} - min_{a_{ij}}} \quad (31)$$

- Calculating the criteria weights

By convention, when the weight of a criterion is equal to zero, this will be equivalent to 1% of the next highest weight. The final weight of each criterion is obtained by adding the partial weights obtained by DMs:

$$w_c = \sum_{i=1}^{n} \sum_{l=1}^{k} a_{il} \quad (32)$$

2.5. MEREC

The MEREC method is an objective method that considers the impact of removing a criterion on the performance values of decision alternatives based on the remaining criteria, in contrast to other objective methods that assign weights to criteria by controlling the variance in the performance of the alternative [23]. The criterion that induces the greatest change is the most significant and thus given the highest weight. Another difference is that the logarithmic function is used in the method and performance values that are negative or zero require a conversion to a positive value [17]. One benefit of this method is its simplicity, as it does not necessitate intricate computations and can be executed with ease.

The MEREC method involves the following steps:

- Defining the decision matrix

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1j} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2j} & \cdots & x_{2m} \\ \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\ x_{i1} & x_{i2} & \cdots & x_{ij} & \cdots & x_{im} \\ \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nj} & \cdots & x_{nm} \end{bmatrix} \tag{33}$$

- Normalizing the decision matrix

$$n_{ij} = \begin{cases} \frac{\min_k x_{kj}}{x_{ij}} & (for\ beneficial\ criteria) \\ \frac{x_{ij}}{\max_k x_{kj}} & (for\ non-beneficial\ criteria) \end{cases} \tag{34}$$

- Calculating overall performance values of alternatives

$$S_i = ln\left(1 + \left(\frac{1}{m}\sum_j \left|ln\left(n_{ij}^x\right)\right|\right)\right) \tag{35}$$

- Calculating the performance of the alternatives by removing each criterion

$$S'_{ij} = ln\left(1 + \left(\frac{1}{m}\sum_{k,k\neq j} |ln(n_{ik}^x)|\right)\right) \tag{36}$$

- Calculating the summation of absolute deviations

$$E_j = \sum_i \left|S'_{ij} - S_i\right| \tag{37}$$

- Calculating the criteria weights

$$w_j = \frac{E_j}{\sum_k E_k} \tag{38}$$

3. Methodology

The present study provides a comprehensive review of the novel weighting methods, namely, CILOS, IDOCRIW, FUCOM, LBWA, SAPEVO-M, and MEREC. In the last decade, the BWM method has also been proposed, but there are two main reasons why this method was excluded in this study. Firstly, there already exists a review study on BWM in the literature [6]. Secondly, during the initial idea stage of this study, the number of publications related to the BWM method was also examined in the databases, and approximately 500 publications were found. The approach used in this study is to examine all publications one by one with content analysis, except for bibliometric analysis, and examining such a dense corpus of publications produced for a single method would not be holistic when compared to the number of publications of other methods in the study.

To begin with, utilizing bibliometric indicators, including annual production, sources, authors, countries, affiliations, and publications, a comprehensive review is conducted. The most common indicators are the number of publications and citations per year or per research component (such as sources, authors, affiliations) where citations are indicators of "impact and influence", and the number of publications serve for "productivity" [24]. Despite being descriptive, these analyses acknowledge the significance of several components in a research field. The study then proceeds to furnish detailed findings on the application areas of the aforementioned methods, their use with other MCDM techniques, as well as their applications in fuzzy and hybrid contexts, which are ascertained via content analysis.

The flowchart of the methodology is illustrated in Figure 1.

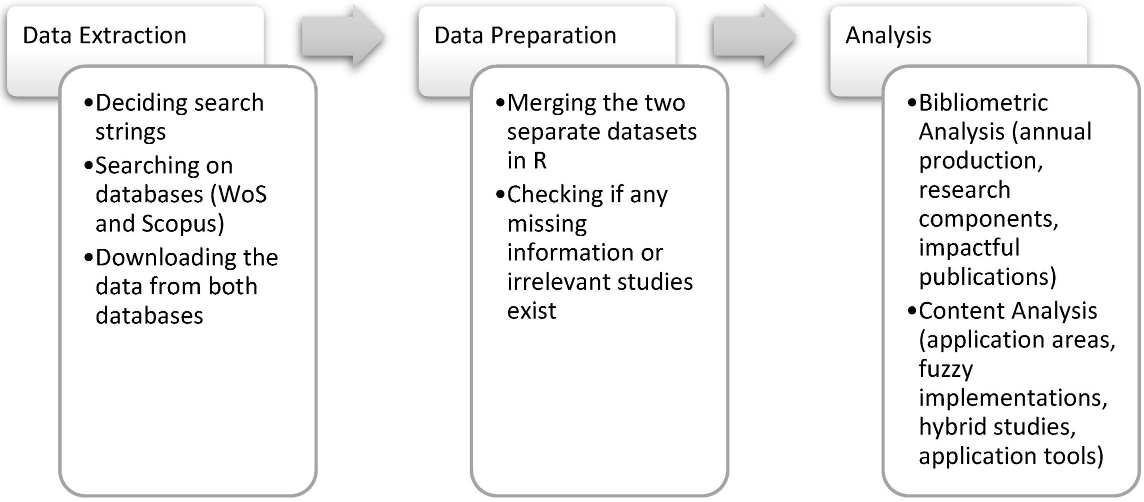

Figure 1. The flowchart of the methodology.

In this study, Web of Science (WoS) and Scopus are both taken into account as databases, since Scopus and WoS are the leading citation databases that are commonly employed in review research [25]. The identification of keywords in this study is based on a review of MCDM-based bibliometric studies published in recent years. To ensure that the search strings accurately captured the relevant information, the abbreviated forms of the methods were initially selected, as prior method oriented MCDM bibliometric studies have searched for abbreviated versions (e.g., [26,27]). Subsequently, additional keywords related to MCDM were included to prevent irrelevant studies from being included in the dataset when the abbreviation of the method is used in other fields. In [1], MCDM-related search query of "multi-attribute decision making" or "madm" or "mcda" or "modm" or "mcdm" or "multi-criteria" or "multi-criteria" or "multiplecriteria" was used. In this study, we incorporated all MCDM-related abbreviations. Furthermore, to ensure comprehensive coverage of DM-related search strings, we utilized the asterisk (*) symbol to search for all variations of multi*, such as multicriteria, multi-criteria, and multiple criteria. We did not include any additional search terms beyond "decision" to encompass other related terms such as decision aiding and decision making.

The search strings are decided as follows:

- On WoS: ("Method's abbreviation") AND ("MCDM" OR "MADM" OR "MCDA" OR "MODM" OR "multi* decision") in Topic search (it searches title, abstract, author keywords, and Keywords Plus), Language = English.
- On Scopus: (TITLE-ABS-KEY({Method's abbreviation}) AND (TITLE-ABS-KEY(MCDM) OR TITLE-ABS-KEY(MADM) OR TITLE-ABS-KEY(MCDA) OR TITLE-ABS-KEY (MODM) OR TITLE-ABS-KEY(multi* AND decision)) AND LANGUAGE(ENGLISH)

After all searches were made on 13 March 2023, all publications in two separate databases (Wos and Scopus) were downloaded with the information of "full record and cited references" for each method. These two separate datasets were combined into a single file in the R Studio (R IDE, version 4.2.2) with the bibliometrix package functions (convert2df and mergeDbSources) used for merging and cleaning. The data set for each method was carefully examined in the final step, and information about the studies with missing data was completed. In addition, irrelevant studies included in the data set, due to incorrect keyword usage, etc., were excluded from the data set. Following this procedure, a total of 160 publications were deemed suitable for both bibliometric and content analyses. The findings from the data extraction process are presented in Table 1, where the combined column encompasses all the publications scrutinized throughout this research.

Table 1. Search results.

Method	WoS	Scopus	Duplicated	Combined (WoS + Scopus-Duplicates)
CILOS	11	11	10	12
IDOCRIW	15	14	14	15
FUCOM	57	62	51	68
LBWA	10	10	6	14
SAPEVO-M	1	11	1	11
MEREC	24	37	21	40
		Total		160

4. Results

This section presents the findings of the review questions. The overview outlines the main characteristics of the publications, while the annual production provides a year-by-year breakdown of publication frequency. The research components section presents the results of the sources, authors, countries, and affiliations of the publications. In addition, the most influential publications are identified. The results of the content analysis are presented in terms of application areas, fuzzy implementations, hybrid studies, and application tools.

4.1. Overview

The overview of the publications is given in Table 2. Based on the results of the search conducted in relevant databases, a total of 12 studies about the CILOS method and 15 studies on the IDOCRIW method were identified. However, upon examining these studies, it was observed that the majority of them (ten publications) were conducted using both methods, as in the first study where these methods were proposed together [15]. When the studies were examined, it is seen that most of the studies (ten publications) are the same (the methods were applied together). Accordingly, two studies were found in which only the CILOS method was applied, and five studies were found in which only the IDOCRIW method was used. Therefore, the findings of these methods are given together.

Table 2. Overview of the publications.

Description	CILOS	IDOCRIW	FUCOM	LBWA	SAPEVO-M	MEREC
Timespan	2016:2022	2016:2023	2018:2023	2019:2023	2020:2023	2021:2023
Documents	12	15	68	14	11	40
Sources	10	14	42	14	9	34
Annual growth rate %	−16.73	−9.43	8.45	0.00	58.74	91.49
Document average age	4.83	3.73	2.1	1.57	1.09	0.8
Average citations per doc	30.42	23.53	18.78	17.86	8.55	5.38
Authors	23	40	177	36	38	135
International co-authorships %	16.67	26.67	36.76	50	9.09	30

The annual growth rate exhibits a negative trend for both CILOS and IDOCRIW. The analysis reveals that the FUCOM method has the highest number of publications (68), followed by MEREC (40).

4.2. Annual Production

The annual production of the methods is demonstrated in Figure 2. It should be noted that for the year 2023, only those publications which were released until 13 March 2023 (i.e., the day of data extraction) are being taken into consideration. Based on the data, there is no discernible trend in the annual distribution of publications related to CILOS and

IDOCRIW. However, there is a noteworthy rise in the number of publications concerning FUCOM and MEREC methods.

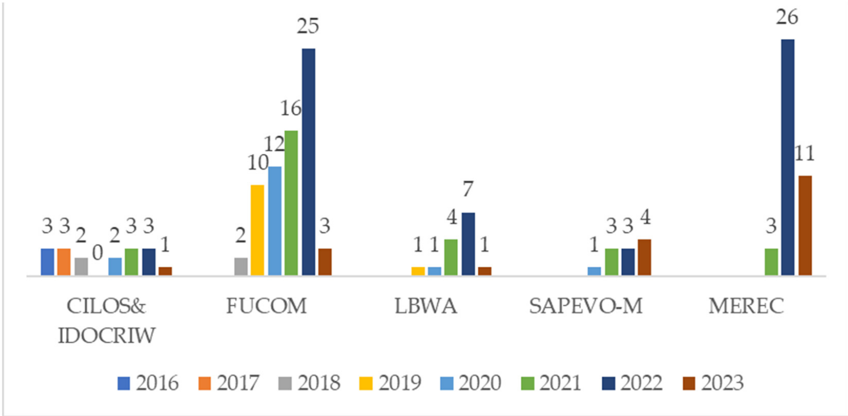

Figure 2. Annual production.

4.3. Research Components (Sources, Authors, Countries, and Affiliations)

The results of the sources and publishers are given below:

- CILOS and IDOCRIW: The *Sustainability and Symmetry* journals are the topmost sources, each contributing two articles to the field. The *International Journal of Information Technology & Decision Making*, in which the seminal article [15] on these methods was published, stands out as the most impactful source with the highest total citation count. *Sustainability and Symmetry* occupy second and third place, respectively, in terms of impact, with total citations of 91 and 64. Of the publishers, MDPI stands out for publishing 35% of the articles (6 out of 17).
- FUCOM: *Symmetry*, in which the method [4] was introduced, has the highest total citation count, with a value of 373, and ranks second in terms of productivity with six publications. *Sustainability* is the most productive source, contributing seven publications. The journal *Decision Making: Applications in Management and Engineering* ranks second in terms of impact, with 220 total citations, and third in terms of productivity with five publications. MDPI stands out as the most relevant publisher with 16 publications, representing 24% of the total.
- LBWA: The LBWA method has been published in various sources, with 14 studies appearing in as many different sources. The journal *Decision Making: Applications in Management and Engineering*, in which the method [5] was introduced, is the most impactful source with a total citation count of 97, followed by *Socio-Economic Planning Sciences* with a value of 52. Elsevier is the most prominent publisher, having produced three works.
- SAPEVO-M: *Frontiers in Artificial Intelligence and Applications* and *Procedia Computer Science* stand out as the most relevant sources, with each publishing two conference papers. *Frontiers in Artificial Intelligence and Applications* and *Pesquisa Operacional* (the journal in which the method [16] was introduced), have both received over 35 citations. Springer is the most relevant publisher, having published three articles.
- MEREC: The most relevant sources for MEREC are the *Lecture Notes in Networks and Systems* journal, which has published five conference papers. *Symmetry*, in which the MEREC method [17] was first introduced, has the highest total citation count, with 79 citations. Among the publishers, Elsevier is the most prolific, with 11 publications, followed by Springer with eight and MDPI with six.

The followings are the results of the authors:

- CILOS and IDOCRIW: For the most productive and impactful authors, Zavadskas E. and Podvezko V. stand out as the authors who published nine and eight articles, respectively, and have received more than 330 total citations. 86% of the authors

(37 authors) published just one article, whereas the most productive author (Zavadskas E.) had nine publications (2%).

- FUCOM: Pamucar D. and Stevic Z. emerge as the most productive and impactful authors, with Pamucar D. having 15 publications and 541 total citations, and Stevic Z. having 16 publications and 534 total citations. The vast majority of the authors (83%) have only one publication, while the top authors represent just 1%.
- LBWA: The most productive and impactful author is Pamucar D. with 11 publications and 222 total citations. Zizovic M., the author of the original paper has the second raw in terms of total citations but only published one article. Ecer F. published four articles and received 76 total citations. The majority of the authors (31 authors, or 86%) have only published one article, while Pamucar D. and Ecer F. correspond to 3%.
- SAPEVO-M: For the most productive and impactful authors Gomes C.F.S. and Dos Santos M. stand out as the authors who published ten and seven articles, respectively, and received more than 59 total citations. 74% of the authors (28 authors) published just one article, whereas the most productive authors (Gomes C.F.S. and Dos Santos M.) correspond to 3%.
- MEREC: Among the authors who have contributed to the literature on the MEREC method, Danh T. and Huy T. stand out with six and five publications, respectively. Notably, Keshavarz-Ghorabaee M. and Zavadskas E., the original developers of the method, have made the most significant impact with a total of 104 and 81 citations, respectively. Similar to other methods, the majority of the authors (81%) have only published one article on the topic, while the most productive authors represent only 1% of the total authors.

The results based on countries and affiliations are provided below:

- CILOS and IDOCRIW: In terms of country-wise productivity and impact, Lithuania emerges as the most productive and impactful country; it has 31 publications and 305 total citations. The productivity is followed by China (5), India (5), and Iran (5). Vilnius Gediminas Technical University (Lithuania), the most productive affiliation, has 29 publications, followed by the University of Tehran (Iran) with 3 publications.
- FUCOM: The most productive and impactful country is Serbia with 449 total citations and 38 publications. Bosnia and Herzegovina is the second most productive country (TC = 359) followed by Turkey (TC = 143). For production, India is the second ($n = 24$) followed by Turkey ($n = 19$). University of East Sarajevo (Bosnia and Herzegovina) and the University of Belgrade (Serbia) stand out with 18 and ten publications, respectively.
- LBWA: The most productive countries are Turkey and Serbia, with 14 and 11 publications, respectively. The most cited country is Serbia with 197 total citations. The University of Belgrade (Serbia) has published the most (seven publications) followed by Afyon Kocatepe University (Turkey) (six publications).
- SAPEVO-M: The application of SAPEVO-M has been primarily limited to Brazil and Portugal, with 38 and two publications, respectively. Among the countries where the method has been applied, Brazil has received the highest citation count of 74. Military Institute of Engineering (Brazil) is the most productive affiliation with six publications, followed by Naval Systems Analysis Center (Brazil) (four publications).
- MEREC: The most productive countries are India and Vietnam, with 19 and 14 publications, respectively. The most cited countries are Lithuania with 80 total citations and India with 37 total citations. Thai Nguyen University of Technology (Vietnam) and Vinh Long University of Technology Education (Vietnam) are the most productive affiliation with seven publications.
- The top research components in this section are summarized in Table 3.

4.4. Publications

An examination of publications concerning these methods reveals the most frequently cited studies, presented in Table 4. The highly cited articles are found to be authored by the originators of the corresponding methods.

Table 3. Summary of the top research components.

Components	CILOS & IDOCRIW	FUCOM	LBWA	SAPEVO-M	MEREC
Productive source	*Sustainability, Symmetry*	*Sustainability*	None (14 different sources)	*Frontiers in Artificial Intelligence and Applications, Procedia Computer Science*	*Lecture Notes in Networks and Systems*
Impactful source	*International Journal of Information Technology & Decision Making*	*Symmetry*	*Decision Making: Applications in Management and Engineering*	*Frontiers in Artificial Intelligence and Applications*	*Symmetry*
Productive publisher	MDPI	MDPI	Elsevier	Springer	MDPI
Productive author	Zavadskas E.	Stevic Z.	Pamucar D.	Gomes C.F.S.	Danh T.
Impactful author	Zavadskas E.	Pamucar D.	Pamucar D.	Gomes C.F.S.	Keshavarz-Ghorabaee M.
Productive country	Lithuania	Serbia	Turkey	Brazil	India
Impactful country	Lithuania	Serbia	Serbia	Brazil	Lithuania
Productive affiliation	Vilnius Gediminas Technical University	University of East Sarajevo	University of Belgrade	Military Institute of Engineering	Thai Nguyen University of Technology, Vinh Long University of Technology Education

Table 4. Top Five Most Cited Publications.

Method	Title	Total Citations
CILOS and IDOCRIW	Integrated Determination of Objective Criteria Weights in MCDM	114
	The Recalculation of the Weights of Criteria in MCDM Methods Using the Bayes Approach	56
	MCDM Assessment of a Healthy and Safe Built Environment According to Sustainable Development Principles a Practical Neighborhood Approach in Vilnius	52
CILOS	Evaluation of Quality Assurance in Contractor Contracts by Multi Attribute Decision Making Methods	46
	Sustainable Assessment of Aerosol Pollution Decrease Applying Multiple Attribute Decision Making Methods	39
FUCOM	A New Model for Determining Weight Coefficients of Criteria in MCDM Models: Full Consistency Method (FUCOM)	315
	A Novel Integrated FUCOM-MARCOS Model for Evaluation of Human Resources in a Transport Company	84
	Prioritizing The Weights of The Evaluation Criteria Under Fuzziness: The Fuzzy Full Consistency Method—FUCOMF	73
	A New Hybrid MCDM Model: Sustainable Supplier Selection in a Construction Company	62
	Assessment of Alternative Fuel Vehicles for Sustainable Road Transportation of United States Using Integrated Fuzzy FUCOM And Neutrosophic Fuzzy MARCOS Methodology	53

Table 4. *Cont.*

Method	Title	Total Citations
LBWA	New Model for Determining Criteria Weights Level Based Weight Assessment (LBWA) Model	97
	An Integrated BWM LBWA COCOSO Framework for Evaluation of Healthcare Sectors in Eastern Europe	52
	LBWA Z-MAIRCA Model Supporting Decision Making in The Army	27
	A Multi-tier Sustainable Food Supplier Selection Model Under Uncertainty	23
	Assessment of Renewable Energy Resources Using New Interval Rough Number Extension of The Level Based Weight Assessment and Combinative Distance based Assessment	21
SAPEVO-M	SAPEVO-M: a group multicriteria ordinal ranking method	35
	Study of the Location of a Second Fleet for The Brazilian Navy: Structuring and Mathematical Modeling Using SAPEVO-M and VIKOR Methods	22
	The SAPEVO-M-NC Method	19
	Investments in Times of Pandemics: An Approach by the SAPEVO-M-NC Method	17
	SAPEVO-H2 A Multi-Criteria Approach Based on Hierarchical Network: Analysis of Aircraft Systems for Brazilian Navy	1
MEREC	Determination of Objective Weights Using a New Method Based on The Removal Effects of Criteria (MEREC)	79
	Fermatean Fuzzy Heronian Mean Operators and MEREC-based Additive Ratio Assessment Method: An Application to Food Waste Treatment Technology Selection	25
	Assessment of Distribution Center Locations Using a Multi-Expert Subjective-Objective Decision-Making Approach	25
	Adapting Urban Transport Planning to The COVID-19 Pandemic: An Integrated Fermatean Fuzzy Model	23
	A Multi-Criteria Decision-Making in Turning Process Using THE MAIRCA EAMR MARCOS and TOPSIS Methods: A Comparative Study	15

4.5. Application Areas

CILOS and IDOCRIW have been applied together in diverse areas, including business economics, such as quality assurance in constructor contracts [28] and construction market performance [29]; environmental studies, such as evaluating a healthy and safe built environment according to sustainable development principles [30]; engineering, such as rotor systems [31] and screw joint parameters [32]; and multidisciplinary applications, such as comparing countries using indicators (the children physical activity and the Human Development Index) [33].

There are also studies in which the methods are not used together and are applied in different areas. CILOS method has also applied in portfolio optimization (business economics) [34] and sustainable evaluation of aerosol pollution decrease (environmental studies) [35]. IDOCRIW method has been used in product ranking based on online customer reviews (business economics) [36] and environmental studies, such as assessment of different cladding materials for growing bell pepper [37], construction and demolition waste management [38], planning the future energy systems [39], and environmental impact evaluation to minimize dam negative impacts [40].

The FUCOM method finds applications in numerous areas. The method has primarily found its application in the area of business economics, as evidenced by the majority of relevant literature. Consumer DM, such as car [41] and smartphone brand selection [42], evaluation of green bonds [43], evaluation of human resources in a transport company [44], human resource information systems [45], green supplier evaluation [46], sustainable supplier selection [47–49], supplier selection [50], selection of forklift in the warehouse [51], selecting automatically guided vehicles in the warehouse [52], evaluation of the special warehouse handling equipment [53], selection of delivery vehicle [54], the selection of transshipment and handling machinery in container terminals [55], transport demand management [56], quality determination in reverse logistics [57], smart logistics applications and demand forecasting [58], optimization of logistics processes [59], oil supply chains [60], selection of a distribution channel [61], location selection for a textile manufacturing facility [62], facilities layout evaluation [63], organizational structure selection [64], business process orientation and management [65], inventory management to increase business efficiency [66], healthcare performance management [67], performance measurement and evaluation of the airlines [68], construction cost cases [69], SWOT model for the strategic decision analysis [70], competitiveness of spa centers [71], farm tourism [72], and media industry (video streaming platforms) [73] studies are applications in this field.

In addition to business economics, FUCOM has also seen relevant studies in environmental studies, such as the assessment of alternative fuel vehicles for sustainable road transportation [74], sustainable sludge treatment [75], sustainable urban mobility plan [76], circular economy and supply chain management in the pharmaceutical industry [77], express packaging recycling [78], floating solar panel energy system installation [79], landfill site selection [80], disposal of healthcare waste [81], healthcare waste treatment [82], renewable energy [83], green innovation [84], biogas facility location selection [85], and evaluation of national parks [86].

Another area of application is engineering, with relevant studies including the following: selecting the most favorable location for construction [87], cloud-based multi-robot path planning [88], spray painting robot selection [89], mineral potential mapping [21], identification of the groundwater potential recharge zones [90], hole turning process [8], evaluation and selection of optimal transport routes for hazardous materials [91], transportation engineering [92,93], sustainable traffic system management and railway infrastructure [94], nontraditional manufacturing methods [95], risk assessment and mitigation for electric power sectors [96], railway infrastructure [97], and reliability management and risk assessment in industries [98]. Apart from these areas, there are other studies, such as selecting a location for a brigade command post [99], a resilience-based model for the healthcare sector [100], and video conferencing tools used for teaching-learning and meetings [101].

LBWA method has been applied in business, economic and environment-related areas, namely, public transportation [102], container port selection [103], micro, small and medium enterprises [104], human resources in a transportation company [105], select equity linked savings scheme funds [106], sustainable food supplier selection [107], waste in fast-moving consumer goods [108], green transportation [109], renewable energy resources [110], and smart cities [111]. There are also defense-related DM studies (location selection for the camp army [112] and weapon system selection [113]) and healthcare [114].

SAPEVO-M method has been used in studies such as defense-related DM (location selection [115] and the analysis of aircraft systems [116,117] for the Brazilian Navy), business economics (financial investment and portfolio management [22], selection of truck for transportation [118]), engineering (computer numeric control router [119]), and environment (the treatment of produced water in oil and gas industry [120]).

MEREC has found diverse applications across fields, encompassing business economics and environmental studies; however, its principal employment has been within the domain of engineering. Applications in the field of business economics are as follows: the financial performance of the hospitality and tourism industries [121], efficiency and productivity of commercial banks [122], evaluation of economic freedom levels of OPEC countries [123], assessment of distribution center locations [124] sustainable smart manufacturing systems for industry 4.0 in small, medium, and micro enterprises [125], portfolio optimization [34], and supplier selection [126]. The following are the applications in the area of environmental studies: mitigating climate change effects of urban transportation [127], identifying the optimal renewable energy power plant location [128], selecting a green renewable energy source [129], selecting offshore wind turbine [130], offshore wind farm site selection [131], circular economy paradigm in European Union countries (environmental economics) [132], and efficiency evaluation of the mineral deposit [133].

MEREC is most widely used in the following applications in engineering: selection of a phase change material [134], selecting truck mixer concrete pump [135], determining the parameters for external cylindrical grinding [136], determining dressing parameters for internal cylindrical grinding [137], dressing process for internal grinding [138], determining input parameters for CBN grinding [139], material selection of a lightweight aircraft wing spar [140], pallet truck selection [141], selecting optimal spray-painting robot [23], milling process [142], selection quality hole by ultrasonic machining process [143], prioritizing solid-state drivers [144], determining the best experiment for turning process [145], plasma arc cutting process optimization [146], selecting the schema of scissors mechanism [147], determining the process input parameters in wire-electrical discharge machining [148], powder-mixed electric discharge machining [149–151], cubic boron nitride grinding [152], and hole turning process [8]. Uses other than applications in these areas are as follows: food waste treatment technology selection [153], urban planning and development, specifically in the context of sustainable smart city development [154], urban transport planning and DM, with a focus on adapting transport plans to the COVID-19 pandemic [155], web and IoT-based hospital location determination [156].

The number of publications pertaining to the application areas is given in Table 5. The table lists the names of application areas with two or more studies, while application areas with only one study are categorized as "other".

Table 5. Areas of applications.

Method	Areas of Application	Number of Publications
CILOS and/or IDOCRIW	Environmental studies	6
	Business economics	4
	Engineering	2
	Other	1

Table 5. *Cont.*

Method	Areas of Application	Number of Publications
FUCOM	Business economics	33
	Engineering	14
	Environmental studies	13
	Other	3
LBWA	Business economics	6
	Environmental studies	4
	Defense	2
	Other	1
SAPEVO-M	Defense	3
	Business economics	2
	Other	2
MEREC	Engineering	21
	Business economics	7
	Environmental studies	7
	Other	4

4.6. Fuzzy Implementations

Fuzzy CILOS and IDOCRIW methods are proposed in [157] with F-ENTROPY. There are other fuzzy studies, such as F-IDOCRIW [38] and IF-IDOCRIW (Intuitionistic Fuzzy) [36].

Fuzzy FUCOM (F-FUCOM) has been applied in many studies [46,55,58,64,66,70,72,75–77,83,94,96,158]. Fuzzy group FUCOM [78], double upper approximated rough number FUCOM [98], q-rung orthopair F-FUCOM [82], picture fuzzy FUCOM [73,101], hesitant fuzzy FUCOM [49], integrated rough group FUCOM [97], interval type-2 F-FUCOM [63], F-FUCOM-Dombi-Bonferroni [56], fermatean F-FUCOM [42], intuitionistic F-FUCOM [53], integrated F-FUCOM [74] are the different fuzzy applications.

Fuzzy applications of the LBWA method have been applied in many studies, such as integrated fuzzy LBWA in a stratification environment (SF-LBWA) [102], picture fuzzy LBWA [109], F-LBWA [103,108], LBWA-D [107,113], spherical fuzzy LBWA [104], interval rough LBWA [110].

The application of the MEREC method with fuzzy logic has been observed, with the following applications being noteworthy: type-2 neutrosophic number MEREC [127], fermatean fuzzy set MEREC [153–155], single-valued neutrosophic sets MEREC [140], PV-SPSS-MEREC [128], I2TL-MEREC (interval 2-tuple linguistic) [130], and Q-ROF-MEREC-RS (q-rung orthopair fuzzy sets) [125].

4.7. Hybrid Studies

For the other weighting methods, CILOS and IDOCRIW methods have been used together with ENTROPY method in the majority of the studies [15,28–33,159,160]. Fuzzy AHP [28,159], AHP [159], CRITIC [160], and WEBIRA [33] methods are also applied with CILOS and IDOCRIW. For the ranking methods, CILOS and IDOCRIW methods have been applied together with COPRAS, SAW, TOPSIS, and EDAS [28–32,34,159] in many studies. CILOS and IDOCRIW methods are also applied with cluster analysis [33], the rank average method, Borda count and Copeland's method [30]. Additionally, sentiment analysis is used with IDOCRIW method [36].

FUCOM method has been applied with other MCDM methods. For the weighting methods, FUCOM is applied with CRITIC [54,85,93], PIPRECIA [89], FUZZY PIPRECIA [65,70,93,94], SWARA [43,89], SWARA-G [79], MEREC [8], F-GRC-DANP (grey relational coefficient-DEMATEL-ANP) [78], BWM, F-BWM, AHP, and F-AHP [4,43,46,69,83,89,90,158]. There are also grey implementations of FUCOM method in [45,59,79].

Upon analysis of the ranking methods employed in conjunction with FUCOM, it is observed that the MARCOS method is predominantly utilized (MARCOS [44,54,61,67,69,84,93], F-MARCOS [55,64,70,71,94], interval type-2 F-MARCOS [63], and neutrosophic F-MARCOS [74]). Apart from MARCOS, TOPSIS, WASPAS, and MABAC methods are also frequently used together with FUCOM (TOPSIS [8,43,69,89,91], F-TOPSIS [41,75,95], grey TOPSIS [45], vector-aided TOPSIS [83], double upper approximated rough number TOPSIS [98], and hesitant fuzzy TOPSIS [49]; WASPAS [50,51,92], F-WASPAS [95], intuitionistic F-WASPAS [53], and rough WASPAS [47,52]; MABAC [8,85,86,91], F-MABAC [87], picture fuzzy MABAC [73], rough MABAC [47,52], Z-MABAC [99], and hesitant fuzzy MABAC [49]).

The other methods are as follows: EDAS (F-EDAS [66,78], interval rough EDAS [58]), COPRAS (COPRAS [43,89], rough COPRAS [47]), COCOSO (COCOSO [8,89], F-COCOSO [76]), CODAS (CODAS [80], fermatean fuzzy CODAS [42]), ROUGH SAW [47,48,52], GRA [45,79], F-GRA [75], VIKOR [89], FUZZY VIKOR [96], MAIRCA [8], integrated rough group MAIRCA [97], ROUGH ARAS [47], CRADIS [81], picture fuzzy PROBID [101], AHP [68], MOORA mapping [21,89], MOOSRA mapping [21], PROMETHEE [89], DNMA [82], PIV-F [62], EAMR [8], F-WSM [72], F-PRSRV (Projection Ranking by Similarity to Referencing Vector) [75], and grey WSM [45].

Other than MCDM methods, methods in different fields have been used in FUCOM studies, such as ABC analysis [66], fuzzy quality function deployment [60,77,100], SERVQUAL, Cronbach Alpha [57], and SWOT analysis [59,70].

LBWA method is applied with other weighting (SWARA-D [107] and BWM [114]) and ranking methods (F-COCOSO [102,103], COCOSO [114], interval rough CODAS [110], MABAC-D [113], MARCOS [106], MARCOS-D [107], MULTI-MOOSRAL in spherical fuzzy and TOPSIS [104], RADERIA (new ranking method introduced) [55], picture fuzz COCOSO [109], Z-MAIRCA [112], EDAS-G [111]) for MCDM. There are other methods rather than MCDM, such as Wilcoxon matched pair t-test and Kendall's concordance coefficient [106].

SAPEVO-M is used with VIKOR [115], PROMETHEE [118], and WASPAS [119,161] ranking methods. DELPHI method is also used with SAPEVO-M [120].

For MEREC, it has been seen that the most popular of the weighting methods used in studies with MEREC are ENTROPY [133,134,136,138,142,144,145,151–153] and CRITIC [34,132,133,144,146]. Other methods are SWARA II [122,124], I2TL-SWARA II (interval 2-tuple linguistic) [130], simplified BWM [131], Symmetry Point of Criterion (SPC) [133], SECA and CILOS [34], FUCOM [8], and AHP [126].

An examination of ranking methods used in conjunction with MEREC reveals the widespread utilization of TOPSIS and MARCOS methods. The studies in which these methods have been applied are as follows: TOPSIS [8,34,126,134,136,138,145,148,149,151,152,156], fermatean fuzzy TOPSIS [154], MARCOS [34,122,132,136,138,144,145,147,149,151], DNMARCOS (double normalized MARCOS) [135], type-2 neutrosophic number MARCOS [127], single-valued neutrosophic sets MARCOS [140]. Additional employed ranking methods include MAIRCA [8,34,138,145,149,151,152], MABAC [8,23,34,136,137,143,150], COCOSO [8,23,34,143], GREY-COCOSO [121], cumulative prospect theory COCOSO [130], fermatean fuzzy COCOSO [155], EAMR [8,138,145,146,151,152], WASPAS [34,124,139,141], VIKOR [23,134,143], COPRAS [23,34,134], single-valued neutrosophic sets COPRAS [140], CODAS [23,34], ARAS [34], fermatean fuzzy set ARAS [153], DNMA [123], and Q-ROF-DNMA [125]. Other methods, including the clustering analysis [132] and Spearman's rank and Wojciech-Salabun coefficient [144], exist alongside MCDM.

4.8. Application Tools

The application tools for the methods are given in Table 6.

Table 6. Application tools of the methods.

Tool	Name	Application	Access
Python	PyMCDM (package)	MEREC, CILOS, and IDOCRIW	[162]
Python	pyDecision (package)	IDOCRIW	https://pypi.org/project/pyDecision/ (accessed on 10 May 2023)
Python	Crispyn (package)	MEREC, CILOS, and IDOCRIW	[163]
Web	SADEMON	SAPEVO-M	[164]
R	Sapevom (package)	SAPEVO-M	https://cran.r-project.org/web/packages/sapevom/vignettes/SAPEVO-M_Example.html (accessed on 10 May 2023)

PyMCDM is a Python 3 library that provides numerous traditional and novel ranking and weighting methods, as well as normalization methods and correlation coefficients, for MCDM problems. Apart from MEREC, CILOS, and IDOCRIW, equal/mean, ENTROPY, standard deviation, angle, Gini coefficient and statistical variance weights options are included in the package. Similarly, pyDecision is a Python library that is based on various MCDM methods. Some weighting methods in this package are AHP, fuzzy AHP, BWM, CRITIC, DEMATEL, and fuzzy DEMATEL. Crispyn (CRIteria Significance determining in PYthoN), another Python 3 library, offers objective weighting methods and includes a Stochastic Multicriteria Acceptability Analysis. It includes all the weighting methods in the PyMCDM package, as well as CRITIC and coefficient of variation weighting method options. Lastly, SAPEVO-M has both a computational web platform (SADEMON) and an R package (Sapevom).

5. Discussion and Conclusions

MCDM techniques continue to be utilized by researchers in diverse fields, with both traditional and novel methods being employed to advance the discipline. Given the importance of monitoring such methodological developments, this study aims to contribute to the field through a comprehensive review of novel weighting-based MCDM methods, namely, CILOS, IDOCRIW, FUCOM, LBWA, SAPEVO-M, and MEREC. The relevant keywords are searched across the WoS and Scopus databases, resulting in the analysis of 160 related publications.

While the annual growth rate displays a negative trend for both CILOS and IDOCRIW, FUCOM, and MEREC emerge as the most frequently studied methods. Furthermore, SAPEVO-M exhibits the lowest rate of international co-authorships, with Brazil being the primary country of application. The results provide valuable knowledge on relevant and cited sources, authors, countries, and affiliations for each method. The most productive and impactful sources vary depending on the method, with *Symmetry* journal ranking highest for FUCOM and MEREC, and third for CILOS and IDOCRIW. MDPI emerges as the most relevant publisher for FUCOM, CILOS, and IDOCRIW, while Elsevier is the top choice for LBWA and MEREC, and Springer for SAPEVO-M. Notably, certain authors such as Zavadskas E. and Pamucar D. stand out as key contributors. In terms of country-specific trends, Lithuania and Serbia emerge as prominent countries.

Regarding highly cited publications, in addition to those authored by the method creators, fuzzy implementations of the methods have garnered attention, with the exception of the SAPEVO-M method. Fuzzy studies have been conducted on all methods except SAPEVO-M and are elaborated upon under the section pertaining to fuzzy implementations.

Furthermore, diverse applications of these methods are observed in fields such as business economics, environment, and engineering. For instance, while the FUCOM method has primarily found its application in business economics, MEREC's principal employment has been within the domain of engineering. Also, other areas, such as defense-related DM studies, have been applied by using LBWA and SAPEVO-M. Moreover, hybrid studies involving the combination of multiple methods are common, with ENTROPY being the top weighting method in which MEREC, CILOS, and IDOCRIW are most frequently used together. FUCOM has been predominantly used in conjunction with BWM and AHP. With respect to ranking methods, it is observed that MEREC is often used in conjunction with the TOPSIS and MARCOS methods. Similarly, MARCOS is predominantly combined with FUCOM, while the CILOS and IDOCRIW methods are frequently applied together with COPRAS, SAW, TOPSIS, and EDAS. Furthermore, it is worth noting that studies employing these methods have also incorporated other techniques such as cluster analysis, sentiment analysis, SWOT analysis, and various statistical tests.

Finally, the study examines the tools developed for the application of these methods, with Python and R packages being commonly utilized for CILOS, IDOCRIW, SAPEVO-M, and MEREC, while no tool has been found for LBWA and FUCOM.

From a theoretical perspective, this study contributes to the identification of novel MCDM methods and their associated trends, research components, as well as their applications across various fields, such as business economics, engineering, and defense-related decision-making. This information can aid researchers in identifying gaps in the literature and applying novel methods that address specific DM scenarios.

There are opportunities for further development of the new methods, such as developing fuzzy applications for SAPEVO-M and creating application tools for LBWA and FUCOM. However, existing tools for other novel weighting methods can be used for practical applications of these methods. The application tools, such as packages, can be particularly useful for researchers and practitioners interested in implementing these methods.

One of the practical implications for managers or decision-makers is the presentation of a portfolio of criteria weighting methods that may be integrated into other methods of weighting or ranking alternatives. In this study, hybrid methods in which new methods are frequently used together are determined. This information can help managers identify the most appropriate MCDM method for their specific needs and applications. In addition, the application areas of the methods can be examined, and the methods discussed for similar problems can be tried. As mentioned in the literature, it is important to proceed with several methods and make comparisons in terms of the reliability of the results. For this reason, managers can benefit from hybrid models that can be applied together with the methods they think are suitable for the problem. Multicriteria methods are tools that support decision-making by organizing complex information and enabling managers to make more rational decisions. However, it is important to note that the ultimate decision is still made by the managers, not the methods themselves. A balanced approach that combines subjective and objective methods has emerged as a trend in the development of new methods, as it allows for the integration of manager preferences with mathematical algorithms. It is not the researchers' aim to promote a particular method, but rather to present the available options and demonstrate how they can be used in decision-making processes.

Future research may explore how the methods described in this study can be integrated with traditional multi-criteria methods. In addition, the following two research questions can be explored:

What are the advantages and disadvantages of using new weighting methods compared to more common/traditional weighting methods?

What strategies can be developed by academia to disseminate such methods in diverse national contexts?

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Abbreviations

The following abbreviations are used in this manuscript:

AHP	Analytic Hierarchy Process
ANP	Analytical Network Process
ARAS	Additive Ratio ASsessment
BWM	Best-Worst Method
CILOS	Criterion Impact Loss
COCOSO	COmbined COmpromise SOlution
CODAS	COmbinative Distance-based Assessment
COPRAS	Complex Proportional Assessment
CRADIS	Compromise Ranking of Alternatives from Distance to Ideal Solution
DEMATEL	Decision-Making Trial and Evaluation Laboratory
DM	Decision-making
DMs	Decision-makers
DNMA	Double Normalization-based Multiple Aggregation
EAMR	Evaluation by an Area-based Method of Ranking
EDAS	Evaluation based on Distance from Average Solution
FUCOM	Full Consistency Method
GRA	Grey Relational Analysis
IDOCRIW	Integrated Determination of Objective CRIteria Weights
LBWA	Level Based Weight Assessment
MABAC	Multi-Attributive Border Approximation area Comparison
MAIRCA	MultiAtributive Ideal-Real Comparative Analysis
MARCOS	Measurement of Alternatives and Ranking according to COmpromise Solution
MCDM	Multi-Criteria Decision-Making
MEREC	Method Based on the Removal Effects of Criteria
MOORA	Multi-Objective Optimization by Ratio Analysis
MOORA	Multi-Objective Optimization on the basis of Ratio Analysis
MOOSRA	Multi-Objective Optimization on the basis of Simple Ratio Analysis
PIPRECIA	PIvot Pairwise RElative Criteria Importance Assessment
RADERIA	Ranking Alternatives by Defining Relations between the Ideal and Anti-ideal alternative
SAPEVO-M	Simple Aggregation of Preferences Expressed by Ordinal Vectors—Multi Decision Makers
SAW	Simple Additive Weighting
SECA	Simultaneous Evaluation of Criteria and Alternatives
SWARA	Step-wise Weight Assessment Ratio Analysis
TOPSIS	Technique for Order of Preference by Similarity to Ideal Solution
VIKOR	VlseKriterijumska Optimizacija I Kompromisno Resenje (Serbian)
WASPAS	Weighted Aggregated Sum Product Assessment
WEBIRA	WEight Balancing Indicator Ranks Accordance

References

1. Basílio, M.P.; Pereira, V.; Costa, H.G.; Santos, M.; Ghosh, A. A Systematic Review of the Applications of Multi-Criteria Decision Aid Methods (1977–2022). *Electronics* **2022**, *11*, 1720. [CrossRef]
2. Singh, A.; Malik, S.K. Major MCDM Techniques and Their Application-A Review. *IOSR J. Eng.* **2014**, *4*, 15–25. [CrossRef]
3. Mardani, A.; Jusoh, A.; Nor, K.; Khalifah, Z.; Zakwan, N.; Valipour, A. Multiple Criteria Decision-Making Techniques and Their Applications–a Review of the Literature from 2000 to 2014. *Econ. Res.-Ekon. Istraživanja* **2015**, *28*, 516–571. [CrossRef]
4. Pamučar, D.; Stević, Ž.; Sremac, S. A New Model for Determining Weight Coefficients of Criteria in Mcdm Models: Full Consistency Method (Fucom). *Symmetry* **2018**, *10*, 393. [CrossRef]
5. Žižović, M.; Pamucar, D. New Model for Determining Criteria Weights: Level Based Weight Assessment (LBWA) Model. *Decis. Mak. Appl. Manag. Eng.* **2019**, *2*, 126–137. [CrossRef]
6. Singh, M.; Pant, M. A Review of Selected Weighing Methods in MCDM with a Case Study. *Int. J. Syst. Assur. Eng. Manag.* **2021**, *12*, 126–144. [CrossRef]
7. Kornyshova, E.; Salinesi, C. MCDM Techniques Selection Approaches: State of the Art. In Proceedings of the 2007 IEEE Symposium on Computational Intelligence in Multi-Criteria Decision-Making, Honolulu, HI, USA, 1–5 April 2007; IEEE: New York, NY, USA, 2007; pp. 22–29.

8. Do, D.T.; Nguyen, N.-T. Applying Cocoso, Mabac, Mairca, Eamr, Topsis and Weight Determination Methods for Multi-Criteria Decision Making in Hole Turning Process. *Strojnícky Časopis-J. Mech. Eng.* **2022**, *72*, 15–40. [CrossRef]
9. Pöyhönen, M.; Hämäläinen, R.P. On the Convergence of Multiattribute Weighting Methods. *Eur. J. Oper. Res.* **2001**, *129*, 569–585. [CrossRef]
10. Baydaş, M.; Elma, O.E. An Objectıve Criteria Proposal for the Comparison of MCDM and Weighting Methods in Financial Performance Measurement: An Application in Borsa Istanbul. *Decis. Mak. Appl. Manag. Eng.* **2021**, *4*, 257–279. [CrossRef]
11. Ghaleb, A.M.; Kaid, H.; Alsamhan, A.; Mian, S.H.; Hidri, L. Assessment and Comparison of Various MCDM Approaches in the Selection of Manufacturing Process. *Adv. Mater. Sci. Eng.* **2020**, *2020*, 4039253. [CrossRef]
12. Vujičić, M.D.; Papić, M.Z.; Blagojević, M.D. Comparative Analysis of Objective Techniques for Criteria Weighing in Two MCDM Methods on Example of an Air Conditioner Selection. *Tehnika* **2017**, *72*, 422–429. [CrossRef]
13. Jahan, A.; Mustapha, F.; Sapuan, S.M.; Ismail, M.Y.; Bahraminasab, M. A Framework for Weighting of Criteria in Ranking Stage of Material Selection Process. *Int. J. Adv. Manuf. Technol.* **2012**, *58*, 411–420. [CrossRef]
14. Rezaei, J. Best-Worst Multi-Criteria Decision-Making Method. *Omega* **2015**, *53*, 49–57. [CrossRef]
15. Zavadskas, E.K.; Podvezko, V. Integrated Determination of Objective Criteria Weights in MCDM. *Int. J. Inf. Technol. Decis. Mak.* **2016**, *15*, 267–283. [CrossRef]
16. Gomes, C.F.S.; dos Santos, M.; Teixeira, L.F.H.d.S.d.B.; Sanseverino, A.M.; Barcelos, M.R.d.S. SAPEVO-M: A Group Multicriteria Ordinal Ranking Method. *Pesqui. Oper.* **2020**, *40*, e226524. [CrossRef]
17. Keshavarz-Ghorabaee, M.; Amiri, M.; Zavadskas, E.K.; Turskis, Z.; Antucheviciene, J. Determination of Objective Weights Using a New Method Based on the Removal Effects of Criteria (MEREC). *Symmetry* **2021**, *13*, 525. [CrossRef]
18. Odu, G.O. Weighting Methods for Multi-Criteria Decision Making Technique. *J. Appl. Sci. Environ. Manag.* **2019**, *23*, 1449–1457. [CrossRef]
19. Mardani, A.; Nilashi, M.; Zakuan, N.; Loganathan, N.; Soheilirad, S.; Saman, M.Z.M.; Ibrahim, O. A Systematic Review and Meta-Analysis of SWARA and WASPAS Methods: Theory and Applications with Recent Fuzzy Developments. *Appl. Soft Comput.* **2017**, *57*, 265–292. [CrossRef]
20. Mirkin, B.G. *Problema Grupovogo Vibora*; Nauka: Moscow, Russia, 1974.
21. Feizi, F.; Karbalaei-Ramezanali, A.A.; Farhadi, S. FUCOM-MOORA and FUCOM-MOOSRA: New MCDM-Based Knowledge-Driven Procedures for Mineral Potential Mapping in Greenfields. *SN Appl. Sci.* **2021**, *3*, 1–19. [CrossRef]
22. Do Nascimento Maêda, S.M.; Basílio, M.P.; de Araújo Costa, I.P.; Lellis Moreira, M.Â.; dos Santos, M.; Gomes, C.F.S.; de Almeida, I.D.P.; de Araújo Costa, A.P. Investments in Times of Pandemics: An Approach by the SAPEVO-M-NC Method. In Proceedings of the 2nd Conference on Modern Management Based on Big Data, MMBD 2021 and 3rd Conference on Machine Learning and Intelligent Systems, MLIS 2021, Quanzhou, China, 8–11 November 2021; pp. 162–168.
23. Shanmugasundar, G.; Sapkota, G.; Čep, R.; Kalita, K. Application of MEREC in Multi-Criteria Selection of Optimal Spray-Painting Robot. *Processes* **2022**, *10*, 1172. [CrossRef]
24. Donthu, N.; Kumar, S.; Mukherjee, D.; Pandey, N.; Lim, W.M. How to Conduct a Bibliometric Analysis: An Overview and Guidelines. *J. Bus. Res.* **2021**, *133*, 285–296. [CrossRef]
25. Zhu, J.; Liu, W. A Tale of Two Databases: The Use of Web of Science and Scopus in Academic Papers. *Scientometrics* **2020**, *123*, 321–335. [CrossRef]
26. Koca, G.; Yıldırım, S. Bibliometric Analysis of DEMA^{TEL} Method. *Decis. Mak. Appl. Manag. Eng.* **2021**, *4*, 85–103. [CrossRef]
27. Ferreira, F.A.; Santos, S.P. Two Decades on the MACBETH Approach: A Bibliometric Analysis. *Ann. Oper. Res.* **2021**, *296*, 901–925. [CrossRef]
28. Trinkūnienė, E.; Podvezko, V.; Zavadskas, E.K.; Jokšienė, I.; Vinogradova, I.; Trinkūnas, V. Evaluation of Quality Assurance in Contractor Contracts by Multi-Attribute Decision-Making Methods. *Econ. Res.-Ekon. Istraživanja* **2017**, *30*, 1152–1180. [CrossRef]
29. Podvezko, V.; Kildienė, S.; Zavadskas, E.K. Assessing the Performance of the Construction Sectors in the Baltic States and Poland. *Panoeconomicus* **2017**, *64*, 493–512. [CrossRef]
30. Zavadskas, E.K.; Cavallaro, F.; Podvezko, V.; Ubarte, I.; Kaklauskas, A. MCDM Assessment of a Healthy and Safe Built Environment According to Sustainable Development Principles: A Practical Neighborhood Approach in Vilnius. *Sustainability* **2017**, *9*, 702. [CrossRef]
31. Čereška, A.; Podvezko, V.; Zavadskas, E.K. Operating Characteristics Analysis of Rotor Systems Using MCDM Methods. *Stud. Inform. Control* **2016**, *25*, 60. [CrossRef]
32. Čereška, A.; Podviezko, A.; Zavadskas, E.K. Assessment of Different Metal Screw Joint Parameters by Using Multiple Criteria Analysis Methods. *Metals* **2018**, *8*, 318. [CrossRef]
33. Krylovas, A.; Kosareva, N.; Dadelo, S. European Countries Ranking and Clustering Solution by Children's Physical Activity and Human Development Index Using Entropy-Based Methods. *Mathematics* **2020**, *8*, 1705. [CrossRef]
34. Ozcalici, M. Allocation with Multi Criteria Decision Making Techniques. *Decis. Mak. Appl. Manag. Eng.* **2022**, *5*, 78–119. [CrossRef]
35. Čereška, A.; Zavadskas, E.K.; Cavallaro, F.; Podvezko, V.; Tetsman, I.; Grinbergienė, I. Sustainable Assessment of Aerosol Pollution Decrease Applying Multiple Attribute Decision-Making Methods. *Sustainability* **2016**, *8*, 586. [CrossRef]
36. Dahooie, J.H.; Raafat, R.; Qorbani, A.R.; Daim, T. An Intuitionistic Fuzzy Data-Driven Product Ranking Model Using Sentiment Analysis and Multi-Criteria Decision-Making. *Technol. Forecast. Soc. Chang.* **2021**, *173*, 121158. [CrossRef]

37. Shukla, C.; Gupta, D.; Pandey, B.K.; Bhakar, S.R. Suitability Assessment of Different Cladding Materials for Growing Bell Pepper under Protected Cultivation Structures Using Multi-Criteria Decision-Making Technique. *Environ. Dev. Sustain.* **2023**, 1–21. [CrossRef]
38. Eghbali-Zarch, M.; Tavakkoli-Moghaddam, R.; Dehghan-Sanej, K.; Kaboli, A. Prioritizing the Effective Strategies for Construction and Demolition Waste Management Using Fuzzy IDOCRIW and WASPAS Methods. *Eng. Constr. Archit. Manag.* **2022**, *29*, 1109–1138. [CrossRef]
39. Ali, T.; Aghaloo, K.; Chiu, Y.-R.; Ahmad, M. Lessons Learned from the COVID-19 Pandemic in Planning the Future Energy Systems of Developing Countries Using an Integrated MCDM Approach in the off-Grid Areas of Bangladesh. *Renew. Energy* **2022**, *189*, 25–38. [CrossRef]
40. Eslami, V.; Ashofteh, P.-S.; Golfam, P.; Loáiciga, H.A. Multi-Criteria Decision-Making Approach for Environmental Impact Assessment to Reduce the Adverse Effects of Dams. *Water Resour. Manag.* **2021**, *35*, 4085–4110. [CrossRef]
41. Ali, Y.; Mehmood, B.; Huzaifa, M.; Yasir, U.; Khan, A.U. Development of a new hybrid multi criteria decision-making method for a car selection scenario. *Facta Univ.-Ser. Mech. Eng.* **2020**, *18*, 357–373. [CrossRef]
42. Biswas, S.; Pamucar, D.; Kar, S.; Sana, S.S. A New Integrated FUCOM–CODAS Framework with Fermatean Fuzzy Information for Multi-Criteria Group Decision-Making. *Symmetry* **2021**, *13*, 2430. [CrossRef]
43. Lombardi Netto, A.; Salomon, V.A.P.; Ortiz Barrios, M.A. Multi-Criteria Analysis of Green Bonds: Hybrid Multi-Method Applications. *Sustainability* **2021**, *13*, 10512. [CrossRef]
44. Stević, Ž.; Brković, N. A Novel Integrated FUCOM-MARCOS Model for Evaluation of Human Resources in a Transport Company. *Logistics* **2020**, *4*, 4. [CrossRef]
45. Esangbedo, M.O.; Bai, S.; Mirjalili, S.; Wang, Z. Evaluation of Human Resource Information Systems Using Grey Ordinal Pairwise Comparison MCDM Methods. *Expert Syst. Appl.* **2021**, *182*, 115151. [CrossRef]
46. Pamucar, D.; Ecer, F. Prioritizing the Weights of the Evaluation Criteria under Fuzziness: The Fuzzy Full Consistency Method–FUCOM-F. *Facta Univ. Ser. Mech. Eng.* **2020**, *18*, 419–437. [CrossRef]
47. Matić, B.; Jovanović, S.; Das, D.K.; Zavadskas, E.K.; Stević, Ž.; Sremac, S.; Marinković, M. A New Hybrid MCDM Model: Sustainable Supplier Selection in a Construction Company. *Symmetry* **2019**, *11*, 353. [CrossRef]
48. Stević, Ž.; Durmić, E.; Gajić, M.; Pamučar, D.; Puška, A. A Novel Multi-Criteria Decision-Making Model: Interval Rough SAW Method for Sustainable Supplier Selection. *Information* **2019**, *10*, 292. [CrossRef]
49. Mishra, A.R.; Saha, A.; Rani, P.; Pamucar, D.; Dutta, D.; Hezam, I.M. Sustainable Supplier Selection Using HF-DEA-FOCUM-MABAC Technique: A Case Study in the Auto-Making Industry. *Soft Comput.* **2022**, *26*, 8821–8840. [CrossRef]
50. Erceg, Ž.; Mularifović, F. Integrated MCDM Model for Processes Optimization in Supply Chain Management in Wood Company. *Oper. Res. Eng. Sci. Theory Appl.* **2019**, *2*, 37–50. [CrossRef]
51. Fazlollahtabar, H.; Smailbašić, A.; Stević, Ž. FUCOM Method in Group Decision-Making: Selection of Forklift in a Warehouse. *Decis. Mak. Appl. Manag. Eng.* **2019**, *2*, 49–65. [CrossRef]
52. Zavadskas, E.K.; Nunić, Z.; Stjepanović, Ž.; Prentkovskis, O. A Novel Rough Range of Value Method (R-ROV) for Selecting Automatically Guided Vehicles (AGVs). *Stud. Inform. Control* **2018**, *27*, 385–394. [CrossRef]
53. Hashemkhani Zolfani, S.; Görçün, Ö.F.; Küçükönder, H. Evaluation of the Special Warehouse Handling Equipment (Turret Trucks) Using Integrated FUCOM and WASPAS Techniques Based on Intuitionistic Fuzzy Dombi Aggregation Operators. *Arab. J. Sci. Eng.* **2023**, 1–35. [CrossRef]
54. Stevie, Z.; Kotoric, M.; Stojic, G.; Sremac, S. Selection of Delivery Vehicle Using Integrated Objective-Subjective MCDM Model. In Proceedings of the 25th International Scientific Conference TRANSPORT MEANS 2021, Kaunas, Lithuania, 6–8 October 2021.
55. Vesković, S.; Stević, Ž.; Nunić, Z.; Milinković, S.; Mladenović, D. A Novel Integrated Large-Scale Group MCDM Model under Fuzzy Environment for Selection of Reach Stacker in a Container Terminal. *Appl. Intell.* **2022**, *52*, 13543–13567. [CrossRef]
56. Pamucar, D.; Deveci, M.; Canıtez, F.; Bozanic, D. A Fuzzy Full Consistency Method-Dombi-Bonferroni Model for Prioritizing Transportation Demand Management Measures. *Appl. Soft Comput.* **2020**, *87*, 105952. [CrossRef]
57. Stević, Ž.; Tanackov, I.; Puška, A.; Jovanov, G.; Vasiljević, J.; Lojaničić, D. Development of Modified SERVQUAL–MCDM Model for Quality Determination in Reverse Logistics. *Sustainability* **2021**, *13*, 5734. [CrossRef]
58. Stević, Ž.; Korucuk, S.; Karamaşa, Ç.; Demir, E.; Zavadskas, E.K. A Novel Integrated Fuzzy-Rough MCDM Model for Assessment of Barriers Related to Smart Logistics Applications and Demand Forecasting Method in the COVID-19 Period. *Int. J. Inf. Technol. Decis. Mak.* **2022**, *21*, 1647–1678. [CrossRef]
59. Popović, V.; Pamučar, D.; Stević, Ž.; Lukovac, V.; Jovković, S. Multicriteria Optimization of Logistics Processes Using a Grey FUCOM-SWOT Model. *Symmetry* **2022**, *14*, 794. [CrossRef]
60. Baig, M.M.U.; Ali, Y.; Ur Rehman, O. Enhancing resilience of oil supply chains in the context of developing countries. *Oper. Res. Eng. Sci. Theory Appl.* **2022**, *5*, 69–89. [CrossRef]
61. Dalic, I.; Stevic, Z.; Erceg, Z.; Macura, P.; Terzic, S. Selection of a distribution channel using the integrated fucom-marcos model. *Int. Rev.* **2020**, 80–96. [CrossRef]
62. Ulutaş, A.; Karakuş, C.B. Location Selection for a Textile Manufacturing Facility with GIS Based on Hybrid MCDM Approach [Selecția Locației Pentru o Companie Textilă Cu GIS Bazată Pe Abordarea Modelului Hibrid MCDM]. *Ind. Textila* **2021**, *72*, 126–132. [CrossRef]

63. Gölcük, İ.; Durmaz, E.D.; Şahin, R. Interval Type-2 Fuzzy Development of FUCOM and Activity Relationship Charts along with MARCOS for Facilities Layout Evaluation. *Appl. Soft Comput.* **2022**, *128*, 109414. [CrossRef]
64. Khosravi, M.; Haqbin, A.; Zare, Z.; Shojaei, P. Selecting the Most Suitable Organizational Structure for Hospitals: An Integrated Fuzzy FUCOM-MARCOS Method. *Cost Eff. Resour. Alloc.* **2022**, *20*, 1–16. [CrossRef]
65. Dobrosavljević, A.; Urošević, S.; Vuković, M.; Talijan, M.; Marin, D. Evaluation of Process Orientation Dimensions in the Apparel Industry. *Sustain. Switz.* **2020**, *12*, 4145. [CrossRef]
66. Vukasović, D.; Gligović, D.; Terzić, S.; Stević, Ž.; Macura, P. A Novel Fuzzy MCDM Model for Inventory Management in Order to Increase Business Efficiency. *Technol. Econ. Dev. Econ.* **2021**, *27*, 386–401. [CrossRef]
67. Abdullah, A.; Ahmad, S.; Athar, M.A.; Rajpoot, N.; Talib, F. Healthcare Performance Management Using Integrated FUCOM-MARCOS Approach: The Case of India. *Int. J. Health Plann. Manag.* **2022**, *37*, 2635–2668. [CrossRef] [PubMed]
68. Badi, I.; Abdulshahed, A. Ranking the Libyan Airlines by Using Full Consistency Method (FUCOM) and Analytical Hierarchy Process (AHP). *Oper. Res. Eng. Sci. Theory Appl.* **2019**, *2*, 1–14. [CrossRef]
69. Anysz, H.; Nica\l, A.; Stević, Ž.; Grzegorzewski, M.; Sikora, K. Pareto Optimal Decisions in Multi-Criteria Decision Making Explained with Construction Cost Cases. *Symmetry* **2020**, *13*, 46. [CrossRef]
70. Đalić, I.; Stević, Ž.; Ateljević, J.; Turskis, Z.; Zavadskas, E.K.; Mardani, A. A Novel Integrated Mcdm-Swot-Tows Model for the Strategic Decision Analysis in Transportation Company. *Facta Univ. Ser. Mech. Eng.* **2021**, *19*, 401–422. [CrossRef]
71. Mijajlović, M.; Puška, A.; Stević, Ž.; Marinković, D.; Doljanica, D.; Jovanović, S.V.; Stojanović, I.; Beširović, J. Determining the Competitiveness of Spa-Centers in Order to Achieve Sustainability Using a Fuzzy Multi-Criteria Decision-Making Model. *Sustainability* **2020**, *12*, 8584. [CrossRef]
72. Ocampo, L. Full Consistency Method (FUCOM) and Weighted Sum under Fuzzy Information for Evaluating the Sustainability of Farm Tourism Sites. *Soft Comput.* **2022**, *26*, 12481–12508. [CrossRef]
73. Biswas, S.; Pamucar, D.; Kar, S. A Preference-Based Comparison of Select over-the-Top Video Streaming Platforms with Picture Fuzzy Information. *Int. J. Commun. Netw. Distrib. Syst.* **2022**, *28*, 414–458. [CrossRef]
74. Pamucar, D.; Ecer, F.; Deveci, M. Assessment of Alternative Fuel Vehicles for Sustainable Road Transportation of United States Using Integrated Fuzzy FUCOM and Neutrosophic Fuzzy MARCOS Methodology. *Sci. Total Environ.* **2021**, *788*, 147763. [CrossRef]
75. Tang, C.; Xu, D.; Chen, N. Sustainability Prioritization of Sewage Sludge to Energy Scenarios with Hybrid-Data Consideration: A Fuzzy Decision-Making Framework Based on Full Consistency Method and Fusion Ranking Model. *Environ. Sci. Pollut. Res.* **2021**, *28*, 5548–5565. [CrossRef] [PubMed]
76. Demir, G.; Damjanovic, M.; Matovic, B.; Vujadinovic, R. Toward Sustainable Urban Mobility by Using Fuzzy-FUCOM and Fuzzy-CoCoSo Methods: The Case of the SUMP Podgorica. *Sustainability* **2022**, *14*, 4972. [CrossRef]
77. Khan, F.; Ali, Y. Implementation of the Circular Supply Chain Management in the Pharmaceutical Industry. *Environ. Dev. Sustain.* **2022**, *24*, 13705–13731. [CrossRef] [PubMed]
78. Ling, L.; Anping, R.; Di, X. Proposal of a Hybrid Decision-Making Framework for the Prioritization of Express Packaging Recycling Patterns. *Environ. Dev. Sustain.* **2023**, *25*, 2610–2647. [CrossRef]
79. Cao, Q.; Esangbedo, M.O.; Bai, S.; Esangbedo, C.O. Grey SWARA-FUCOM Weighting Method for Contractor Selection MCDM Problem: A Case Study of Floating Solar Panel Energy System Installation. *Energies* **2019**, *12*, 2481. [CrossRef]
80. Badi, I.; Kridish, M. Landfill Site Selection Using a Novel FUCOM-CODAS Model: A Case Study in Libya. *Sci. Afr.* **2020**, *9*, e00537. [CrossRef]
81. Puška, A.; Stević, Ž.; Pamučar, D. Evaluation and Selection of Healthcare Waste Incinerators Using Extended Sustainability Criteria and Multi-Criteria Analysis Methods. *Environ. Dev. Sustain.* **2022**, *24*, 11195–11225. [CrossRef]
82. Saha, A.; Mishra, A.R.; Rani, P.; Hezam, I.M.; Cavallaro, F. A Q-Rung Orthopair Fuzzy FUCOM Double Normalization-Based Multi-Aggregation Method for Healthcare Waste Treatment Method Selection. *Sustainability* **2022**, *14*, 4171. [CrossRef]
83. Xu, D.; Ren, J.; Dong, L.; Yang, Y. Portfolio Selection of Renewable Energy-Powered Desalination Systems with Sustainability Perspective: A Novel MADM-Based Framework under Data Uncertainties. *J. Clean. Prod.* **2020**, *275*, 124114. [CrossRef]
84. Badi, I.; Muhammad, L.J.; Abubakar, M.; Bakır, M. Measuring Sustainability Performance Indicators Using FUCOM-MARCOS Methods. *Oper. Res. Eng. Sci. Theory Appl.* **2022**, *5*, 99–116. [CrossRef]
85. Tulun, Ş.; Arsu, T.; Gürbüz, E. Selection of the Most Suitable Biogas Facility Location with the Geographical Information System and Multi-Criteria Decision-Making Methods: A Case Study of Konya Closed Basin, Turkey. *Biomass Convers. Biorefinery* **2022**, *13*, 3439–3461. [CrossRef]
86. Chakraborty, S.; Sarkar, B.; Chakraborty, S. A FUCOM-MABAC-Based Integrated Approach for Performance Evaluation of the Indian National Parks. *OPSEARCH* **2022**, *60*, 125–154. [CrossRef]
87. Bozanic, D.; Tešić, D.; Kočić, J. Multi-Criteria FUCOM–Fuzzy MABAC Model for the Selection of Location for Construction of Single-Span Bailey Bridge. *Decis. Mak. Appl. Manag. Eng.* **2019**, *2*, 132–146. [CrossRef]
88. Zagradjanin, N.; Pamucar, D.; Jovanovic, K. Cloud-Based Multi-Robot Path Planning in Complex and Crowded Environment with Multi-Criteria Decision Making Using Full Consistency Method. *Symmetry* **2019**, *11*, 1241. [CrossRef]
89. Kumar, V.; Kalita, K.; Chatterjee, P.; Zavadskas, E.K.; Chakraborty, S. A SWARA-CoCoSo-Based Approach for Spray Painting Robot Selection. *Informatica* **2022**, *33*, 35–54. [CrossRef]

90. Akbari, M.; Meshram, S.G.; Krishna, R.S.; Pradhan, B.; Shadeed, S.; Khedher, K.M.; Sepehri, M.; Ildoromi, A.R.; Alimerzaei, F.; Darabi, F. Identification of the Groundwater Potential Recharge Zones Using MCDM Models: Full Consistency Method (FUCOM), Best Worst Method (BWM) and Analytic Hierarchy Process (AHP). *Water Resour. Manag.* **2021**, *35*, 4727–4745. [CrossRef]
91. Noureddine, M.; Ristic, M. Route Planning for Hazardous Materials Transportation: Multi-Criteria Decision-Making Approach. *Decis. Mak. Appl. Manag. Eng.* **2019**, *2*, 66–85. [CrossRef]
92. Nenadic, D. Ranking Dangerous Sections of the Road Using the Mcdm Model. *Decis. Mak. Appl. Manag. Eng.* **2019**, *2*, 115–131. [CrossRef]
93. Stević, Ž.; Subotić, M.; Tanackov, I.; Sremac, S.; Ristić, B.; Simić, S. Evaluation of two-lane road sections in terms of traffic risk using an integrated mcdm model. *Transport* **2022**, *37*, 318–329. [CrossRef]
94. Blagojevic, A.; Kasalica, S.; Stevic, Z.; Trickovic, G.; Pavelkic, V. Evaluation of Safety Degree at Railway Crossings in Order to Achieve Sustainable Traffic Management: A Novel Integrated Fuzzy MCDM Model. *Sustainability* **2021**, *13*, 832. [CrossRef]
95. Sofuoglu, M.A. Fuzzy Applications of FUCOM Method in Manufacturing Environment. *J. Polytech.-Politek. Derg.* **2020**, *23*, 189–195. [CrossRef]
96. Rehman, O.U.; Ali, Y.; Sabir, M. Risk Assessment and Mitigation for Electric Power Sectors: A Developing Country's Perspective. *Int. J. Crit. Infrastruct. Prot.* **2022**, *36*, 100507. [CrossRef]
97. Pamucar, D.; Macura, D.; Tavana, M.; Bozanic, D.; Knezevic, N. An Integrated Rough Group Multicriteria Decision-Making Model for the Ex-Ante Prioritization of Infrastructure Projects: The Serbian Railways Case. *Socioecon. Plann. Sci.* **2022**, *79*, 101098. [CrossRef]
98. Dhalmahapatra, K.; Garg, A.; Singh, K.; Xavier, N.F.; Maiti, J. An Integrated RFUCOM—RTOPSIS Approach for Failure Modes and Effects Analysis: A Case of Manufacturing Industry. *Reliab. Eng. Syst. Saf.* **2022**, *221*, 108333. [CrossRef]
99. Bozanic, D.; Tešić, D.; Milić, A. Multicriteria Decision Making Model with Z-Numbers Based on FUCOM and MABAC Model. *Decis. Mak. Appl. Manag. Eng.* **2020**, *3*, 19–36. [CrossRef]
100. Khan, F.; Ali, Y.; Pamucar, D. A New Fuzzy FUCOM-QFD Approach for Evaluating Strategies to Enhance the Resilience of the Healthcare Sector to Combat the COVID-19 Pandemic. *Kybernetes* **2022**, *51*, 1429–1451. [CrossRef]
101. Biswas, S.; Pamucar, D.; Chowdhury, P.; Kar, S. A New Decision Support Framework with Picture Fuzzy Information: Comparison of Video Conferencing Platforms for Higher Education in India. *Discrete Dyn. Nat. Soc.* **2021**, *2021*, 2046097. [CrossRef]
102. Pamucar, D.; Gokasar, I.; Torkayesh, A.E.; Deveci, M.; Martínez, L.; Wu, Q. Prioritization of Unmanned Aerial Vehicles in Transportation Systems Using the Integrated Stratified Fuzzy Rough Decision-Making Approach with the Hamacher Operator. *Inf. Sci.* **2023**, *622*, 374–404. [CrossRef]
103. Pamucar, D.; Görçün, Ö.F. Evaluation of the European Container Ports Using a New Hybrid Fuzzy LBWA-CoCoSo'B Techniques. *Expert Syst. Appl.* **2022**, *203*, 117463. [CrossRef]
104. Biswas, S.; Pamučar, D.; Božanić, D.; Halder, B. A New Spherical Fuzzy LBWA-MULTIMOOSRAL Framework: Application in Evaluation of Leanness of MSMEs in India. *Math. Probl. Eng.* **2022**, *2022*, 1–17. [CrossRef]
105. Jakovljevic, V.; Zizovic, M.; Pamucar, D.; Stević, Ž.; Albijanic, M. Evaluation of Human Resources in Transportation Companies Using Multi-Criteria Model for Ranking Alternatives by Defining Relations between Ideal and Anti-Ideal Alternative (RADERIA). *Mathematics* **2021**, *9*, 976. [CrossRef]
106. Biswas, S.; Pamucar, D.; Mukhopadhyaya, J.N. A Multi-Criteria-Based Analytical Study of the Impact of COVID-19 on ELSS Fund Performance. *Int. J. Manag. Decis. Mak.* **2022**, *21*, 339–378. [CrossRef]
107. Yazdani, M.; Pamucar, D.; Chatterjee, P.; Torkayesh, A.E. A Multi-Tier Sustainable Food Supplier Selection Model under Uncertainty. *Oper. Manag. Res.* **2022**, *15*, 116–145. [CrossRef]
108. Ögel, İ.Y.; Ecer, F.; Özgöz, A.A. Identifying the Leading Retailer-Based Food Waste Causes in Different Perishable Fast-Moving Consumer Goods' Categories: Application of the F-LBWA Methodology. *Environ. Sci. Pollut. Res.* **2022**, *30*, 32656–32672. [CrossRef]
109. Korucuk, S.; Aytekin, A.; Ecer, F.; Pamucar, D.S.S.; Karamaşa, Ç. Assessment of Ideal Smart Network Strategies for Logistics Companies Using an Integrated Picture Fuzzy LBWA–CoCoSo Framework. *Manag. Decis.* **2022**, *61*, 1434–1462. [CrossRef]
110. Ecer, F.; Pamucar, D.; Mardani, A.; Alrasheedi, M. Assessment of Renewable Energy Resources Using New Interval Rough Number Extension of the Level Based Weight Assessment and Combinative Distance-Based Assessment. *Renew. Energy* **2021**, *170*, 1156–1177. [CrossRef]
111. Adali, E.A.; Öztaş, G.Z.; Öztaş, T.; Tuş, A. Assessment of European Cities from a Smartness Perspective: An Integrated Grey MCDM Approach. *Sustain. Cities Soc.* **2022**, *84*, 104021. [CrossRef]
112. Božanić, D.; Jurišić, D.; Erkić, D. LBWA–Z-MAIRCA Model Supporting Decision Making in the Army. *Oper. Res. Eng. Sci. Theory Appl.* **2020**, *3*, 87–110. [CrossRef]
113. Hristov, N.; Pamucar, D.; Amine, M. Application of a D Number Based LBWA Model and an Interval MABAC Model in Selection of an Automatic Cannon for Integration into Combat Vehicles. *Def. Sci. J.* **2021**, *71*, 34–45. [CrossRef]
114. Torkayesh, A.E.; Pamucar, D.; Ecer, F.; Chatterjee, P. An Integrated BWM-LBWA-CoCoSo Framework for Evaluation of Healthcare Sectors in Eastern Europe. *Socioecon. Plann. Sci.* **2021**, *78*, 101052. [CrossRef]

115. De Almeida, I.D.P.; de Corriça, J.V.P.; Costa, A.P.d.A.; Costa, I.P.d.A.; Maêda, S.M.d.N.; Gomes, C.F.S.; dos Santos, M. Study of the Location of a Second Fleet for the Brazilian Navy: Structuring and Mathematical Modeling Using SAPEVO-M and VIKOR Methods. In Proceedings of the Production Research: 10th International Conference of Production Research-Americas, ICPR-Americas 2020, Bahía Blanca, Argentina, 9–11 December 2020; Revised Selected Papers, Part II; Springer: Cham, Switzerland, 2021; pp. 113–124.
116. Moreira, M.Â.L.; Gomes, C.F.S.; Pereira, M.T.; dos Santos, M. SAPEVO-H2 a Multi-Criteria Approach Based on Hierarchical Network: Analysis of Aircraft Systems for Brazilian Navy. In *Innovations in Industrial Engineering II*; Springer: Cham, Switzerland, 2022; pp. 61–74.
117. Moreira, M.Â.L.; Silva, F.C.A.; de Araújo Costa, I.P.; Gomes, C.F.S.; Santos, M. dos SAPEVO-H^2 a Multi-Criteria Systematic Based on a Hierarchical Structure: Decision-Making Analysis for Assessing Anti-RPAS Strategies in Sensing Environments. *Processes* **2023**, *11*, 352. [CrossRef]
118. De Siqueira Silva, M.J.; Tomaz, P.P.M.; Diniz, B.P.; de Moura Pereira, D.A.; do Monte, D.M.M.; dos Santos, M.; Gomes, C.F.S.; de Oliveira Costa, D. A Comparative Analysis of Multicriteria Methods AHP-TOPSIS-2N, PROMETHEE-SAPEVO-M1 and SAPEVO-M: Selection of a Truck for Transport of Live Cargo. *Procedia Comput. Sci.* **2022**, *214*, 86–92. [CrossRef]
119. Dos Santos Hermogenes, L.R.; de Araújo Costa, I.P.; dos Santos, M.; Gomes, C.F.S. Acquisition of a CNC Router for a Joinery in Brazil: An Approach from VFT, SAPEVO-M and WASPAS Methods. In *Pervasive Computing and Social Networking: Proceedings of ICPCSN 2022*; Springer: Singapore, 2022; pp. 219–232.
120. Macêdo-Júnior, R.O.; Serpa, F.S.; Santos, B.L.P.; de Vasconcelos, C.R.; Silva, G.F.; Ruzene, D.S.; Silva, D.P. Produced Water Treatment and Its Green Future in the Oil and Gas Industry: A Multi-Criteria Decision-Making Study. *Int. J. Environ. Sci. Technol.* **2022**, *20*, 1369–1384. [CrossRef]
121. Ghosh, S.; Bhattacharya, M. Analyzing the Impact of COVID-19 on the Financial Performance of the Hospitality and Tourism Industries: An Ensemble MCDM Approach in the Indian Context. *Int. J. Contemp. Hosp. Manag.* **2022**, *34*, 3113–3142. [CrossRef]
122. Unlu, U.; Yalcin, N.; Avsarligil, N. Analysis of Efficiency and Productivity of Commercial Banks in Turkey Pre- and during COVID-19 with an Integrated MCDM Approach. *Mathematics* **2022**, *10*, 2300. [CrossRef]
123. Ecer, F.; Hashemkhani Zolfani, S. Evaluating economic freedom via a multi-criteria merec-dnma model-based composite system: Case of opec countries. *Technol. Econ. Dev. Econ.* **2022**, *28*, 1158–1181. [CrossRef]
124. Keshavarz-Ghorabaee, M. Assessment of Distribution Center Locations Using a Multi-Expert Subjective-Objective Decision-Making Approach. *Sci. Rep.* **2021**, *11*, 19461. [CrossRef]
125. Yang, L.; Zou, H.; Shang, C.; Ye, X.; Rani, P. Adoption of Information and Digital Technologies for Sustainable Smart Manufacturing Systems for Industry 4.0 in Small, Medium, and Micro Enterprises (SMMEs). *Technol. Forecast. Soc. Chang.* **2023**, *188*, 122308. [CrossRef]
126. Behera, D.K.; Beura, S. Supplier Selection for an Industry Using MCDM Techniques. *Mater. Today Proc.* **2023**, *74*, 901–909. [CrossRef]
127. Simic, V.; Gokasar, I.; Deveci, M.; Svadlenka, L. Mitigating Climate Change Effects of Urban Transportation Using a Type-2 Neutrosophic MEREC-MARCOS Model. *IEEE Trans. Eng. Manag.* **2022**. Early Access. [CrossRef]
128. Narayanamoorthy, S.; Parthasarathy, T.N.; Pragathi, S.; Shanmugam, P.; Baleanu, D.; Ahmadian, A.; Kang, D. The Novel Augmented Fermatean MCDM Perspectives for Identifying the Optimal Renewable Energy Power Plant Location. *Sustain. Energy Technol. Assess.* **2022**, *53*, 102488. [CrossRef]
129. Goswami, S.S.; Mohanty, S.K.; Behera, D.K. Selection of a Green Renewable Energy Source in India with the Help of MEREC Integrated PIV MCDM Tool. *Mater. Today-Proc.* **2022**, *52*, 1153–1160. [CrossRef]
130. Yu, Y.; Wu, S.; Yu, J.; Xu, Y.; Song, L.; Xu, W. A Hybrid Multi-Criteria Decision-Making Framework for Offshore Wind Turbine Selection: A Case Study in China. *Appl. Energy* **2022**, *328*, 120173. [CrossRef]
131. Yu, Y.; Wu, S.; Yu, J.; Chen, H.; Zeng, Q.; Xu, Y.; Ding, H. An Integrated MCDM Framework Based on Interval 2-Tuple Linguistic: A Case of Offshore Wind Farm Site Selection in China. *Process Saf. Environ. Prot.* **2022**, *164*, 613–628. [CrossRef]
132. Kaya, S.K.; Aycin, E.; Pamucar, D. Evaluation of Social Factors within the Circular Economy Concept for European Countries. *Cent. Eur. J. Oper. Res.* **2023**, *31*, 73–108. [CrossRef]
133. Gligorić, Z.; Gligorić, M.; Miljanović, I.; Lutovac, S.; Milutinović, A. Assessing Criteria Weights by the Symmetry Point of Criterion (Novel SPC Method)–Application in the Efficiency Evaluation of the Mineral Deposit Multi-Criteria Partitioning Algorithm. *Comput. Model. Eng. Sci.* **2023**, *136*, 955–979. [CrossRef]
134. Nicolalde, J.F.; Cabrera, M.; Martinez-Gomez, J.; Salazar, R.B.; Reyes, E. Selection of a Phase Change Material for Energy Storage by Multi-Criteria Decision Method Regarding the Thermal Comfort in a Vehicle. *J. Energy Storage* **2022**, *51*, 104437. [CrossRef]
135. Ivanovic, B.; Saha, A.; Stevic, Z.; Puska, A.; Zavadskas, E.K. Selection of Truck Mixer Concrete Pump Using Novel MEREC DNMARCOS Model. *Arch. Civ. Mech. Eng.* **2022**, *22*, 173. [CrossRef]
136. Le, H.-A.; Hoang, X.-T.; Trieu, Q.-H.; Pham, D.-L.; Le, X.-H. Determining the Best Dressing Parameters for External Cylindrical Grinding Using MABAC Method. *Appl. Sci.-Basel* **2022**, *12*, 8287. [CrossRef]
137. Linh, N.H.; Huy, T.Q.; Danh, T.H.; Thinh, T.N.H.; Danh, B.T.; Hung, L.X.; Tu, H.X.; Tam, D.T. Determining Best Dressing Parameters for Internal Cylindrical Grinding Using MABAC Method. In *Advances in Engineering Research and Application, Proceedings of the International Conference on Engineering Research and Applications, ICERA 2022, Thai Nguyen, Vietnam, 1–2 December 2022*; Springer: Cham, Switzerland, 2022; pp. 361–368.

138. Nguyen, H.-Q.; Le, X.-H.; Nguyen, T.-T.; Tran, Q.-H.; Vu, N.-P. A Comparative Study on Multi-Criteria Decision-Making in Dressing Process for Internal Grinding. *Machines* **2022**, *10*, 303. [CrossRef]
139. Khai, D.Q.; Danh, T.H.; Danh, B.T.; Cuong, N.M.; Tu, H.X.; Van Trang, N. Determining Best Input Parameters for CBN Grinding Al6106 T6 Using WASPAS Method. In *Advances in Engineering Research and Application, Proceedings of the International Conference on Engineering Research and Applications, ICERA 2022, Thai Nguyen, Vietnam, 1–2 December 2022*; Springer: Cham, Switzerland, 2022; pp. 369–375.
140. Ul Haq, R.S.; Saeed, M.; Mateen, N.; Siddiqui, F.; Naqvi, M.; Yi, J.B.; Ahmed, S. Sustainable Material Selection with Crisp and Ambiguous Data Using Single-Valued Neutrosophic-MEREC-MARCOS Framework. *Appl. Soft Comput.* **2022**, *128*, 109546. [CrossRef]
141. Ulutas, A.; Stanujkic, D.; Karabasevic, D.; Popovic, G.; Novakovic, S. Pallet Truck Selection with MEREC and WISP-S Methods. *Strateg. Manag.* **2022**, *27*, 23–29. [CrossRef]
142. Le, H.K. Multi-Criteria Decision Making in the Milling Process Using the PARIS Method. *Eng. Technol. Appl. Sci. Res.* **2022**, *12*, 9208–9216. [CrossRef]
143. Sapkota, G.; Das, S.; Sharma, A.; Ghadai, R.K. Comparison of Various Multi-Criteria Decision Methods for the Selection of Quality Hole Produced by Ultrasonic Machining Process. *Mater. Today Proc.* **2022**, *58*, 702–708. [CrossRef]
144. Kumar, R.; Goel, P.; Zavadskas, E.K.; Stevic, Z.; Vujovic, V. A New Joint Strategy for Multi-Criteria Decision-Making: A Case Study for Prioritizing Solid-State Drive. *Int. J. Comput. Commun. Control* **2022**, *17*, 5010. [CrossRef]
145. Trung, D.D.; Thinh, H.X. A Multi-Criteria Decision-Making in Turning Process Using the MAIRCA, EAMR, MARCOS and TOPSIS Methods: A Comparative Study. *Adv. Prod. Eng. Manag.* **2021**, *16*, 443–456. [CrossRef]
146. Das, P.P.; Chakraborty, S. A Comparative Assessment of Multicriteria Parametric Optimization Methods for Plasma Arc Cutting Processes. *Decis. Anal. J.* **2023**, *6*, 100190. [CrossRef]
147. Huy, T.Q.; Liem, N.B.; Hau, T.Q.; Cuong, D.Q.; Danh, T.H.; Nga, N.T.T.; Pi, V.N.; Thieu, N.N. Application of MARCOS Method for Selecting the Best Schema of Scissors Mechanism. In *Advances in Engineering Research and Application, Proceedings of the International Conference on Engineering Research and Applications, ICERA 2022, Thai Nguyen, Vietnam, 1–2 December 2022*; Springer: Cham, Switzerland, 2022; pp. 234–243.
148. Huy, T.Q.; Ky, L.H.; Anh, L.H.; Danh, B.T.; Cuong, N.M.; Tu, N.T. Application of TOPSIS Method to Determine Best Alternative in Wire-EDM 90CrSi Tool Steel. In *Advances in Engineering Research and Application, Proceedings of the International Conference on Engineering Research and Applications, ICERA 2022, Thai Nguyen, Vietnam, 1–2 December 2022*; Springer: Cham, Switzerland, 2022; pp. 254–261.
149. Nguyen, H.-Q.; Nguyen, V.-T.; Phan, D.-P.; Tran, Q.-H.; Vu, N.-P. Multi-Criteria Decision Making in the PMEDM Process by Using MARCOS, TOPSIS, and MAIRCA Methods. *Appl. Sci.-Basel* **2022**, *12*, 3720. [CrossRef]
150. Linh, N.H.; Phong, P.D.; Muthuramalingam, T.; Tan, T.M.; Danh, T.H.; Pi, V.N.; Tu, H.X.; Van Tung, N. Determination of Best Input Factors for PMEDM 90CrSi Tool Steel Using MABAC Method. In *Advances in Engineering Research and Application, Proceedings of the International Conference on Engineering Research and Applications, ICERA 2022, Thai Nguyen, Vietnam, 1–2 December 2022*; Springer: Cham, Switzerland, 2022; pp. 335–344.
151. Danh, T.H.; Huy, T.Q.; Lam, P.D.; Cuong, N.M.; Tu, H.X.; Pi, V.N. A Study on Multi-Criteria Decision-Making in Powder Mixed Electric Discharge Machining Cylindrical Shaped Parts. *EUREKA Phys. Eng.* **2022**, 123–129. [CrossRef]
152. Huy, T.Q.; Hien, B.T.; Danh, T.H.; Lam, P.D.; Linh, N.H.; Van Khoa, V.; Hung, L.X.; Pi, V.N. Application of topsis, mairca and eamr methods for multi-criteria decision making in cubic boron nitride grinding. *East.-Eur. J. Enterp. Technol.* **2022**, *3*, 117. [CrossRef]
153. Rani, P.; Mishra, A.R.; Saha, A.; Hezam, I.M.; Pamucar, D. Fermatean Fuzzy Heronian Mean Operators and MEREC-Based Additive Ratio Assessment Method: An Application to Food Waste Treatment Technology Selection. *Int. J. Intell. Syst.* **2022**, *37*, 2612–2647. [CrossRef]
154. Kamali Saraji, M.; Streimikiene, D. A Novel Extended Fermatean Fuzzy Framework for Evaluating the Challenges to Sustainable Smart City Development. In *Real Life Applications of Multiple Criteria Decision Making Techniques in Fuzzy Domain*; Springer: Singapore, 2022; pp. 37–58.
155. Simić, V.; Ivanović, I.; Đorić, V.; Torkayesh, A.E. Adapting Urban Transport Planning to the COVID-19 Pandemic: An Integrated Fermatean Fuzzy Model. *Sustain. Cities Soc.* **2022**, *79*, 103669. [CrossRef] [PubMed]
156. Hadi, A.; Abdullah, M.Z. Web and IoT-Based Hospital Location Determination with Criteria Weight Analysis. *Bull. Electr. Eng. Inform.* **2022**, *11*, 386–395. [CrossRef]
157. Podvezko, V.; Zavadskas, E.K.; Podviezko, A. An extension of the new objective weight assessment methods cilos and idocriw to fuzzy mcdm. *Econ. Comput. Econ. Cybern. Stud. Res.* **2020**, *54*, 59–75.
158. Haqbin, A. Comparing Best-Worst Method and Full Consistency Method in a Fuzzy Environment. *Decis. Sci. Lett.* **2022**, *11*, 181–192. [CrossRef]
159. Vinogradova, I.; Podvezko, V.; Zavadskas, E.K. The Recalculation of the Weights of Criteria in MCDM Methods Using the Bayes Approach. *Symmetry* **2018**, *10*, 205. [CrossRef]
160. Paradowski, B.; Shekhovtsov, A.; Bączkiewicz, A.; Kizielewicz, B.; Sa\labun, W. Similarity Analysis of Methods for Objective Determination of Weights in Multi-Criteria Decision Support Systems. *Symmetry* **2021**, *13*, 1874. [CrossRef]
161. VITORINO, L.; Almeida SILVA, F.C.; Simões GOMES, C.F.; dos SANTOS, M.; LUCAS, S.F. SAPEVO-WASPAS-2N-A PROPOSAL. *Econ. Comput. Econ. Cybern. Stud. Res.* **2022**, *56*, 21–36.

162. Kizielewicz, B.; Shekhovtsov, A.; Sałabun, W. Pymcdm—The Universal Library for Solving Multi-Criteria Decision-Making Problems. *SoftwareX* **2023**, *22*, 101368. [CrossRef]
163. Bączkiewicz, A.; Wątróbski, J. Crispyn—A Python Library for Determining Criteria Significance with Objective Weighting Methods. *SoftwareX* **2022**, *19*, 101166. [CrossRef]
164. Tenório, F.M.; Moreira, M.Â.L.; de Araújo Costa, I.P.; Gomes, C.F.S.; dos Santos, M.; Silva, F.C.A.; da Silva, R.F.; Basilio, M.P. SADEMON: The Computational Web Platform to the SAPEVO-M Method. *Procedia Comput. Sci.* **2022**, *214*, 125–132. [CrossRef]