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A MULTICRITERIA DECISION-MAKING METHOD BASED ON THE STRICT RANKING METRIC PROCEDURE AND THE COMPROMISE LOGIC OF VIKOR

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Abstract. This paper introduces VIKOR-METRIC, a novel group multi-criteria decision-making (MCDA-G) approach designed to overcome two major limitations of conventional methods: the compensatory effects caused by traditional aggregation operators and the rigorous handling of tied alternatives. Classical aggregation techniques, which merge individual evaluation matrices into a single collective matrix through disjunctive or compromise operators, often lead to information loss and compensatory bias. To address these issues, VIKOR-METRIC integrates the VIKOR method with the Strict Ranking Metric Procedure (SRMP). In the proposed framework, VIKOR is first applied independently to each decision maker's evaluation matrix, producing an individual ranking. These individual rankings are then aggregated using the SRMP, which seeks a consensus ranking by minimizing pairwise disagreements. This process avoids direct data fusion while preserving the diversity of individual preferences. Comparative experiments with existing approaches, notably CHEMATRE, highlight the superior performance of VIKOR-METRIC. The proposed method yields more consistent rankings that better reflect collective preferences and remain free from the biases inherent in traditional aggregation. Consequently, VIKOR-METRIC is particularly suitable for complex decision-making contexts where artificial compensation among criteria is undesirable, such as in public policy evaluation or strategic project management.

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1. Introduction

Decision-making in multicriteria contexts often requires aggregating multiple evaluations of a set of alternatives with respect to several criteria [5]. When performed in a group setting, this process becomes even more challenging, as it must simultaneously account for the divergent preferences of decision-makers and the frequently conflicting nature of the criteria involved. Traditional group multicriteria

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decision analysis (MCDA-G) methods generally adopt an aggregative framework: individual evaluation matrices are combined into a single collective matrix using aggregation operators such as the weighted sum or arithmetic mean, after which a multicriteria ranking or selection method is applied [1]. While this approach is widely employed, it suffers from a major drawback—the emergence of compensatory effects, which can obscure significant disagreements among decision-makers or even lead to paradoxical outcomes [6].

Originally developed for single-decision contexts, the VIKOR method has inspired numerous extensions and adaptations over the years [4]. Some of these incorporate fuzzy environments (fuzzy-VIKOR [2]) to better handle uncertainty. Nevertheless, most group-based extensions of VIKOR remain strongly dependent on the preliminary aggregation of individual evaluation matrices, thereby perpetuating the limitations mentioned above.

To address these shortcomings, we propose a novel approach, termed VIKOR-METRIC, designed to enhance the robustness and fairness of group decision-making processes. The proposed method combines two complementary steps: first, applying the VIKOR procedure independently to each decision-maker's evaluation matrix; and second, aggregating the resulting individual rankings using the Strict Ranking Metric Procedure (SRMP), which produces a consensus ordering of alternatives by minimizing pairwise disagreements among decision-makers. This dual-stage strategy not only mitigates compensatory effects but also provides an effective mechanism for resolving ties among alternatives when necessary.

The aim of this paper is to formally introduce the VIKOR-METRIC method, present its theoretical foundations, illustrate its practical implementation through numerical examples, and compare its performance with existing approaches—particularly those based on global aggregation frameworks.

2. State of the art

2.1. **Some aggregation operators.**

An aggregation operator can be viewed as a mathematical function that takes an input, referred to as an argument, and produces a single output representing the overall score of that input. Each input is thus associated with a unique output. The aggregation function is generally expressed as $y = f(x)$, where x denotes the argument and y the aggregated value. The argument x may be a vector of dimension n, that is, $x = (x_1, x_2, ..., x_n)$, where $x_1, x_2, ..., x_n$ are called the components of x.

A wide variety of aggregation operators have been proposed in the literature. However, in the following, we limit our discussion to the most commonly used ones, without claiming exhaustiveness. For a more comprehensive treatment, the reader is referred to [7], [1], and [15].

2.1.1. *Weighted Sum and Average Operators.*

The weighted sum or weighted arithmetic mean is defined by:

$\psi(a_1, ..., a_n = \sum_{i=1}^{n} \omega_i a_i$,where $\omega_i \in [0, 1]$ are weights such that $\sum_{i=1}^{n} \omega_i = 1$ and ψ an agregation function.

Other types of averages exist (geometric, harmonic, etc.), which can all be expressed in the form:

$$M_f(a_1, ..., a_n) = f^{-1}\left(\sum_{i=1}^{n} \omega_i f(a_i)\right), \tag{1}$$

where f is a strictly increasing continuous function et M and M denotes weighted average . All generalized means are idempotent, continuous, and strictly monotonic. Only the weighted sum satisfies stability under linear scale change [9].

2.1.2. *Ordered Weighted Average (OWA).* The OWA (Ordered Weighted Average) operator was introduced by Yager [16]. It is defined by:

$$OWA_\omega(a_1, ..., a_n) = \sum_{i=1}^{n} \omega_i a_{(i)} \tag{2}$$

with $\omega = (\omega_1, ..., \omega_n)$ a weight vector, $\omega_i \in [0, 1]$ such that $\sum_{i=1}^{n} \omega_i = 1$ and where the notation (.) indicates a permutation of the indices such that $a_{(1)} \leq ... \leq a_{(n)}$

Thus, the weight is not applied to the sources but to the rank of the quantities. The following special cases are important:

- $\omega_1 = 1$ (and therefore $\omega_i = 0, i > 0$) : minimum operator;
- $\omega_n = 1$: maximum operator;
- $\omega_i = 1$ for a given i : order statistic of rank i;
- if n is odd , $\omega_{\frac{n+1}{2}} = 1$: median, and if n is even, the median is defined by $\omega_{\frac{n}{2}} = \omega_{\frac{n}{2}+1} = \frac{1}{2}$

  Generally, we have:

$$OWA_\omega^f(a_1, ..., a_n) = f^{-1}\left(\sum_{i=1}^{n} \omega_i f(a_{(i)})\right) \tag{3}$$

  where f is a continuous, strictly increasing function.

2.1.3. *Symmetric Sums.* They were introduced by Sylvert in 1979 [8]. Symmetric sums are defined as continuous, non-decreasing, neutral operators that satisfy $\psi^{(2)}(0, 0) = 0$, $\psi^{(2)}(1, 1) = 1$, and are stable for scale intersection, i.e $\psi(a_1, a_2) = 1 - \psi(1 - a_1, 1 - a_2)$. They are of the form:

$$\psi(a_1, a_2) = \left(1 + \frac{g(1 - a_1, 1 - a_2)}{g(a_1, a_2)}\right)^{-1} \tag{4}$$

where g is an increasing, continuous function with $g(0, 0) = 0$.

2.2. **Description of the VIKOR method.** This section is primarily based on [4]. The VIKOR method (VIseKriterijumska Optimizacija I Kompromisno Resenje, in Serbian, meaning “Multi-Criteria Optimization and Compromise Solution”) is a widely used approach for addressing multicriteria decision-making problems.Developed by Zoran Z. Vukovic in the 1990s, VIKOR facilitates the identification of a solution that represents an optimal compromise among multiple, often conflicting, decision criteria. The method is formulated using the matrix Lp.

2.2.1. *The Lp matrix.* The LP-metric is a concept widely used in optimization, particularly in the context of linear programming (LP). It provides a way to measure the distance between solutions within a solution space [17,18]. In general, it is defined as:

$$L_{pi} = \left\{ \sum_{j=1}^{n} \left[\frac{w_j \left(f_j^* - f_{ij} \right)}{\left(f_j^* - f_j^- \right)} \right]^p \right\}^{1/p} ; \quad i = 1, \ldots, m, 1 \leq P \leq \infty \tag{5}$$

where w_j denotes the weight of the attribute specified by the decision-maker, p represents the LP family parameter, f_{ij} is the value of the i-th alternative on the j-th attribute, f_j^* is the best value of f_{ij}, and f_j^- is the worst value.

The case L_{1i} is introduced as S_i and is given by:

$$S_i = \sum_{j=1}^{n} w_j \frac{\left(f_j^* - f_{ij} \right)}{\left(f_j^* - f_j^- \right)}; \quad i = 1, \ldots, m \tag{6}$$

Similarly, $L_{\infty i}$ is introduced as R_i and is defined by:

$$R_i = \max_j \left[w_j \frac{\left(f_j^* - f_{ij} \right)}{\left(f_j^* - f_j^- \right)} \right]; \quad i = 1, \ldots, m, ; j = 1, \ldots, n \tag{7}$$

2.2.2. *Principle of the VIKOR method.*

- **The f^* and f^- indices**

  For each attribute $j = 1, \ldots, n$, the best value f_{ij} is denoted by f_j^* and the worst value by f_j^-. The indices f_j^* and f_j^- for positive attributes are calculated as follows:

$$\begin{cases} f_j^* = \max_i f_{ij} \\ f_j^- = \min_i f_{ij} \end{cases} ; \quad i = 1, \ldots, m, \ j = 1, \ldots, n \tag{8}$$

  For negative attributes, the indices f_j^* and f_j^- are determined by:

$$\begin{cases} f_j^* = \min_i f_{ij} \\ f_j^- = \max_i f_{ij} \end{cases} ; \quad i = 1, \ldots, m, \ j = 1, \ldots, n \tag{9}$$

- **The S and R indices**

  The S and R indices are computed for each alternative using the equations:

$$S_i = \sum_{j=1}^{n} w_j \frac{f_j^* - f_{ij}}{f_j^* - f_j^-}; \quad i = 1, \ldots, m \tag{10}$$

$$R_i = \max_j \left[w_j \frac{f_j^* - f_{ij}}{f_j^* - f_j^-} \right]; \quad i = 1, \ldots, m, \ j = 1, \ldots, n \tag{11}$$

► **The VIKOR index**

The VIKOR index is also calculated for each alternative as follows:

$$\begin{cases} Q_i = v \times \frac{S_i - S^*}{S^- - S^*} + (1-v) \times \frac{R_i - R^*}{R^- - R^*} \\ S^* = \min_i S_i, \quad S^- = \max_i S_i, \quad R^* = \min_i R_i, \quad R^- = \max_i R_i \end{cases} \tag{12}$$

where v represents the strategic or compromise weight, often set to 0.5.

► **Final Ranking of Alternatives**

In this step, the alternatives are ranked in ascending order based on the values of S, R, and Q. The alternative with the lowest values across the criteria is considered the most preferred.

2.3. **Description of the Strict Ranking Metric Procedure (SRMP).** This metric procedure, proposed in [10], allows aggregating individual preferences into a collective preference without ties, while minimizing disagreements among voters or decision-makers regarding the consensus. The different steps of this metric procedure are as follows:

Let m denote the number of alternatives and n the number of decision-makers.

- **Step 1:** Each decision-maker ranks the alternatives according to their preference order. This produces n rankings, also called profiles. Let $\prod = \pi_1, \pi_2, ..., \pi_n$ be the set of these n preference profiles. We aim to find a ranking π^* that is closest to all π_i, i.e,
$\delta(\pi^*, \pi_i) = \min \delta(\pi, \pi_i)$, where δ is a distance and π is any profile.
We propose to use the distance of the symmetrical difference which can be interpreted as a *distance* of two matrices and in the case of voting this is understood as *disagreement*. [3].
- **Step 2**: Writing preferences in matrix form
Let $\tilde{rg}ij$ denote the rank of alternative a_i in ranking π_j, $i = 1, ..., m$ and $j = 1, ..., n$. Thus, if $\tilde{rg}11 > \tilde{rg}21$, then $a_2 \succ a_1$ in profile π_1, and if $\tilde{rg}11 = \tilde{rg}_{21}$, then $a_2 \approx a_1$ in profile π_1. The rank matrix, denoted $\tilde{Rg}$, is written as:

$$\tilde{R}_g = \begin{pmatrix} & a_1 & a_2 & \cdots & a_n \\ \pi_1 & \tilde{r}_{g_{11}} & \tilde{r}_{g_{12}} & \cdots & \tilde{r}_{g_{1n}} \\ \pi_2 & \tilde{r}_{g_{21}} & \tilde{r}_{g_{22}} & \cdots & \tilde{r}_{g_{2n}} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \pi_m & \tilde{r}_{g_{m1}} & \tilde{r}_{g_{m2}} & \cdots & \tilde{r}_{g_{mn}} \end{pmatrix}$$

-From the data of $\tilde{Rg}$ we write the evaluation or performance matrices of the decision-makers noted M^t and defined by:
$M^t = [m_{ik}^{(t)}]$, $t \in T$ (set of voters) with:

$$m_{ik}^{(t)} = \begin{cases} 1 & \text{if } a_i \succ^{(t)} a_k \\ 0 & \text{if } a_i \approx^{(t)} a_k \\ -1 & \text{if } a_k \succ^{(t)} a_i \end{cases}$$

- **Step 3**: We then generate all the possible permutations that can be formed with the m candidates. Notons Φ l'ensemble de toutes ces permutations aléatoire.
- **Step 4**: The disagreements are calculated using the following formular:
  $\rightarrow$ The distance between two pairs of storage units is calculated as follows:
  $$\delta(\Phi^{(t)}, M^{(t)}) = \sum_{i=1}^{m}\sum_{k=1}^{m} |\phi_{ik}^{(1)} - m_{ik}^{(1)}| \tag{13}$$
  $\rightarrow$ The disagreement also called Delta Blin (δ_{BL}) of the voters on any Φ ranking is calculated as follows:
  $$\delta_{BL}(\Phi, M^{(t)}) = \sum_{t=1}^{s}\sum_{i=1}^{m}\sum_{k=1}^{m} |\phi_{ik} - p_{ik}^{t}|, \text{with here } t \in T \tag{14}$$
  That is to say: $\delta_{BL}(\Phi, M^{(t)}) = \delta(\Phi, M^{(1)}) + \delta(\Phi, M^{(2)}) + ... + \delta(\Phi, M^{(s)})$
  For m candidates, we have a set of disagreements K of cardinal $m!$.
- **Step 5**: Once the disagreements are known, we identify the $\Phi^* \in \Phi$ ranking that allowed us to obtain the minimum number of disagreements. This choice constitutes a ranking of candidates on which there is less disagreement.

3. Presentation of the VIKOR-METRIC Method

3.1. Mathematical Formulation.

Let $A = a_1, a_2, \ldots, a_n$ be the set of alternatives.
Let $D = D_1, D_2, \ldots, D_m$ be the set of decision-makers.
Each decision-maker D_i provides an evaluation matrix $M^{(i)} \in \mathbb{R}^{n\times q}$.
Let π_i be the strict ranking of the alternatives obtained by applying VIKOR to $M^{(i)}$, i.e., a permutation of A.
The set of rankings is therefore $\Pi = \pi_1, \ldots, \pi_m$.
The metric procedure aggregates Π into a consensual ranking π^*. This aggregation follows equations (13) and (14), giving:

$$\pi^* = \arg\min_{\pi\in S_n} \sum_{i=1}^{m} \delta\left(\pi, \pi_i\right) \tag{15}$$

where S_n is the set of all permutations of n elements.

The hybridization consists of applying the VIKOR method to each of the m evaluation matrices of the decision-makers. This produces m rankings of the alternatives. Next, the Strict Ranking Metric Procedure is applied to determine the consensual ranking, i.e., the ranking that minimizes disagreements. This process can be illustrated by the following figure.

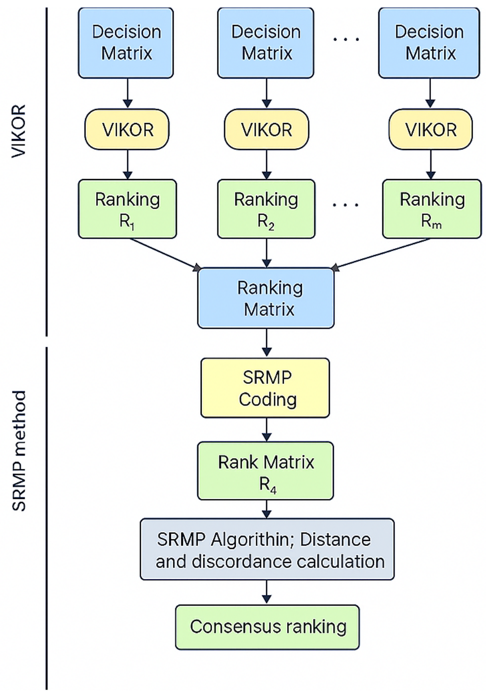

FIGURE 1. The stages of the VIKOR-METRIC method

3.2. **Pseudo code of VIKOR-METRIC.**

Algorithm 1 Pseudo code for the VIKOR-METRIC method

Inputs :

$X^{(k)} = [x_{ij}^{(k)}]$: decision-maker performance matrix k, $k = 1, \ldots, s$

$W^{(k)} = (w_1^{(k)}, \ldots, w_n^{(k)})$: weight of the decision-maker's criteria k

Direction of each criterion (max or min), parameter $v \in [0, 1]$

Release: Consensus ranking of alternatives

1. Phase VIKOR individual

for $k = 1$ **to** s **do**

  Apply the VIKOR method to $(X^{(k)}, W^{(k)})$

  Obtain the ranking $R^{(k)}$ of the alternatives for the decision-maker k.

end for

2. Metric aggregation phase

Define the distance $d_{elta}(R_a, R_b)$ as the size of the symmetrical difference between two rows.

$$d_\Delta(R_a, R_b) = |R_a \,\Delta\, R_b|$$

Find the R^* ranking that minimises :

$$\sum_{k=1}^{s} d_\Delta(R^*, R^{(k)})$$

Return R^* as a consensus ranking

3.3. **Computational Complexity.** The overall computational complexity of the VIKOR-METRIC algorithm is mainly dominated by two stages: the application of the VIKOR procedure for each decision maker and the metric-based aggregation of the resulting rankings. For s decision makers, m alternatives, and n criteria, the execution of the VIKOR method for a single decision maker requires $O(mn)$ operations, leading to a total cost of $O(smn)$ for all decision makers. The subsequent step, which consists in computing the symmetric difference distances between each individual ranking and the consensus ranking, involves $O(sm^2)$ operations.
Hence, the overall computational complexity of the proposed method is given by

$$O(smn + sm^2)$$

This complexity remains polynomial and computationally efficient for problems of moderate size. However, when the number of alternatives m becomes very large, the metric aggregation stage tends to dominate the computation time, making it the most demanding part of the process.

3.4. **Validity of the VIKOR-METRIC method.** The VIKOR-METRIC method checks the following four properties.

Property 1: (*Existence of consensual storage*). Let $\Pi = \pi_1, \ldots, \pi_m$ be a set of strict rankings over n alternatives, and let δ denote the symmetric difference distance defined on the permutation group S_n. Then, there always exists at least one ranking $\pi^* \in S_n$ such that :

$$\pi^* = \arg\min_{\pi \in S_n} \sum_{i=1}^{m} \delta(\pi, \pi_i)$$

Proof. Since the set S_n is finite (it contains $n!$ permutations), and the function

$$f : \pi \mapsto \sum_{i=1}^{m} \delta(\pi, \pi_i)$$

takes a finite number of non-negative real values, it necessarily attains a minimum. Therefore, at least one consensus ranking π^* exists in S_n. □

Property 2 :(*Identical permutation invariance*). If we apply the same permutation π to all the individual arrangements σ_i, then the consensus arrangement σ^* is also transformed by π.
If $\tilde{\sigma}_i = \pi \circ \sigma_i$, then $\tilde{\sigma}^* = \pi \circ \sigma^*$.

Proof. The symmetric difference distance is invariant under any simultaneous permutation of positions applied to the rankings. Hence, the sum of the distances between $\tilde{\sigma}$ and $\tilde{\sigma}_i$ coincides with that between σ and σ_i. It follows that both optimization problems are isomorphic in structure, leading to identical objective values and equivalent optimal solutions. □

Property 3:(*Stability in the case of perfect consensus*)). If all decision-makers produce the same order π_0, then $\pi^* = \pi_0$.

Proof. If $sigma_1 = \sigma_2 = \cdots = \sigma_m = \sigma_0$, then the function to be minimized becomes :

$$\pi \mapsto \sum_{i=1}^{m} \delta(\pi, \pi_0) = m \cdot \delta(\pi, \pi_0) \tag{16}$$

This function is minimized only when $\pi = \pi_0$. □

Property 4:(*Low-noise robustness*). If a single decision-maker slightly modifies his ranking (change of 1 or 2 pairs), then σ^* remains close to the original.

Proof. Consider the cost functions

$F(\sigma) = \sum_{k=1}^{s} d(\sigma, R^{(k)})$ et

$F'(\sigma) = \sum_{k\neq j} d(\sigma, R^{(k)}) + d(\sigma, R'^{(j)})$.

By definition, $\sigma^* = \arg\min_\sigma F(\sigma)$ et $\sigma'^* = \arg\min_\sigma F'(\sigma)$.

By triangular inequality on the metric δ, we have

$|\delta(\sigma, R^{(j)}) - \delta(\sigma, R'^{(j)})| \leq \delta(R^{(j)}, R'^{(j)}) \leq \epsilon$, for all σ.

In particular, for $\sigma = \sigma^*$,

$F'(\sigma^*) = \sum_{k\neq j} d(\sigma^*, R^{(k)}) + d(\sigma^*, R'^{(j)}) \leq \sum_{k=1}^{s} d(\sigma^*, R^{(k)}) + \epsilon = F(\sigma^*) + \epsilon$.

Since σ'^* minimizes F', we have

$$F'(\sigma'^*) \leq F'(\sigma^*) \leq F(\sigma^*) + \epsilon.$$

To bound the distance $\delta(\sigma^*, \sigma'^*)$, note that by the triangle inequality, for all k,

$$|\delta(\sigma'^*, R^{(k)}) - \delta(\sigma^*, R^{(k)})| \leq \delta(\sigma^*, \sigma'^*).$$

In the same way,

$|\delta(\sigma'^*, R'^{(j)}) - \delta(\sigma^*, R^{(j)})| \leq \delta(\sigma^*, \sigma'^*) + \delta(R^{(j)}, R'^{(j)}) \leq \delta(\sigma^*, \sigma'^*) + \epsilon$.

So, summing over all the decision-makers, we obtain

$F'(\sigma'^*) \geq F(\sigma^*) - s \cdot d(\sigma^*, \sigma'^*) - \epsilon$.

Hence

$F(\sigma^*) + \epsilon \geq F'(\sigma'^*) \geq F(\sigma^*) - s \cdot d(\sigma^*, \sigma'^*) - \epsilon$.

This implies that $s \cdot \delta(\sigma^*, \sigma'^*) \geq -2\epsilon$,

and since the distance is always positive,

$\delta(\sigma^*, \sigma'^*) \leq \frac{2\epsilon}{s}$.

So for $s \geq 1$, we have $\delta(\sigma^*, \sigma'^*) \leq 2\epsilon$.

By constant rescheduling, we retain the idea that the consensus solution varies at most proportionally to the initial disturbance. □

4. Digital Applications

4.1. **Didactic example (*Choosing the best pesticide*).** Three farmers cultivate the same cowpea field and wish to treat the plants to improve yield. The problem is to identify a compromise pesticide among the set of approved pesticides available on the market: $A = \{P_1, P_2, P_3, P_4\}$.

These farmers, considered as decision-makers D_1, D_2, and D_3, possess comprehensive knowledge of these pesticides and relevant experience in their use. They define a set of criteria G to evaluate the alternatives: $G = \{g_1; g_2; g_3; g_4; g_5\}$, where g_1: selling price, g_2: effectiveness in eliminating pests, g_5: toxicity of the pesticide (very low, moderate, toxic, very toxic), g_4: duration of action, and g_3: odor of the pesticide (not strong, moderate, strong, very strong).

After modeling the preferences, the following judgment matrices are obtained:

- Decision-makers' judgement matrix

D_1	g_1	g_2	g_3	g_4	g_5
Pesticide 1	6	5	2	4	5
Pesticide 2	5	6	3	3	4
Pesticide 3	7	5	4	6	3
Pesticide 4	6	4	5	3	6
Poids	6	3	2	4	3

Table 1. D_1 judgment matrix

D_2	g_1	g_2	g_3	g_4	g_5
Pesticide 1	7	6	2	3	3
Pesticide 2	6	5	2	5	3
Pesticide 3	6	7	3	6	4
Pesticide 4	5	4	4	4	3
Poids	7	5	3	3	4

Table 2. D_2 judgment matrix

D_3	g_1	g_2	g_3	g_4	g_5
Pesticide 1	6	5	2	4	4
Pesticide 2	7	6	3	5	3
Pesticide 3	6	5	4	3	5
Pesticide 4	5	4	3	6	4
Poids	6	4	2	3	3

Table 3. D_3 judgment matrix

- The Vikor indexes S_i, R_i and Q_i can be calculated as follows:

Alternatives	S_i	R_i	Q_i	Rank
P_1	10.0000	3.0	0.3250	2^{nd}
P_2	12.3333	6.0	1.0000	4^{th}
P_3	5.6666	3.0	0.0000	1^{st}
P_4	10.0000	4.0	0.4916	3^{rd}

Table 4. Ranking of alternatives by decision-maker 1 using the VIKOR method

Alternatives	S_i	R_i	Q_i	Rank
P_1	9.33333	3.0	0.2424	2^{nd}
P_2	11.6666	3.0	0.348484	3^{rd}
P_3	4.0000	3.0	0.0000	1^{st}
P_4	15.0000	6.0	1.0000	4^{th}

Table 5. Ranking of alternatives by decision-maker 2 using the VIKOR method

Alternatives	S_i	R_i	Q_i	Rank
P_1	10.5000	3.0	0.36667	3^{rd}
P_2	5.0000	3.0	0.0000	1^{st}
P_3	8.0000	3.0	0.3666	2^{nd}
P_4	12.5000	6.0	1.0000	4^{th}

Table 6. Ranking of alternatives by decision-maker 3 using the VIKOR method

- This gives the decision-maker ranking matrix M^t defined by the following table:

	1^{st}	2^{nd}	3^{rd}	4^{th}
D_1	P_3	P_1	P_4	P_2
D_2	P_3	P_1	P_2	P_4
D_3	P_2	P_3	P_1	P_4

Table 7. Matrix of decision-maker rankings

- We now apply the SRMP to this matrix to determine the consensus ranking.

  - From the decision-maker ranking table, we determine the rank matrix $\tilde{R}_g$. We obtain:

$$\tilde{R}_g = \begin{pmatrix} & P_1 & P_2 & P_3 & P_4 \\ \pi_1 & 2 & 4 & 1 & 3 \\ \pi_2 & 2 & 3 & 1 & 4 \\ \pi_3 & 3 & 1 & 2 & 4 \end{pmatrix}$$

-Using the following SRMP coding:

$M^t = [m_{ik}^{(t)}]$, $t \in T$ (all decision-makers) with:

$$m_{ik}^{(t)} = \begin{cases} 1 & \text{si } a_i \succ^{(t)} a_k \\ 0 & \text{si } a_i \approx^{(t)} a_k \\ -1 & \text{si } a_k \succ^{(t)} a_i \end{cases}$$

We obtain the adapted evaluation matrices for the three decision-makers, which are respectively:

$$M^{(1)} = \begin{pmatrix} 0 & 1 & -1 & 1 \\ -1 & 0 & -1 & -1 \\ 1 & 1 & 0 & 1 \\ -1 & 1 & -1 & 0 \end{pmatrix} M^{(2)} = \begin{pmatrix} 0 & 1 & -1 & 1 \\ -1 & 0 & -1 & 1 \\ 1 & 1 & 0 & 1 \\ -1 & -1 & -1 & 0 \end{pmatrix} M^{(3)} = \begin{pmatrix} 0 & -1 & -1 & 1 \\ 1 & 0 & 1 & 1 \\ 1 & -1 & 0 & 1 \\ -1 & -1 & -1 & 0 \end{pmatrix}$$

► *The possible permutations with these four candidates are*:

$$Q = \begin{pmatrix} 1 & 2 & 3 & 4 & \\ . & . & . & . & . \\ 4 & 3 & 2 & 1 & \end{pmatrix}$$

-By applying the formulas for calculating distances and disagreements (13) and (14), we obtain the set of disagreements given by the following list:

$\delta_{BL} = \{28, 40, 24, 44, 28, 40, 32, 44, 12, 56, 16, 52, 20, 56, 16, 60, 28, 40, 32, 44, 28, 48, 32, 44\}$

The minimum number of disagreements is therefore 12. Using a Glutton-type algorithm, we identify in the set Q the element Q^* such that $delta_{BL}(Q^*, M^{(t)}) = 12$ avec $t = 1, 2, 3$

This gives us $Q^* = [2 \quad 3 \quad 1 \quad 4]$.

This is the ranking on which decision-makers agree most. We can deduce from this ranking that the best pesticide is P_3 because it ranks first in the consensus ranking.

4.2. **Example 2 (*Singing Contest*).** The problem is to select the best candidate in a singing contest. For this purpose, we have:

★ three decision-makers: Smarty, Bill, and Dèz;

★ five candidates: Reine, Ismael, Moussa, Rene, and Amie;

★ four selection criteria: vocal accuracy, tone quality, rhythm, and stage presence.

The preferences of the decision-makers are expressed in matrix form as follows:

Criteria →	Accuracy of voice	Timbre	Rythm	Stage presence
Actions ↓ \ weight →	3	4	3	5
Reine	6	8	9	4
Ismael	4	5	6	7
Moussa	7	6	8	4
Rene	6	8	4	7
Amie	5	4	7	6

Table 8. Decision-maker evaluation matrix 1. Smarty

Criteria →	Accuracy of voice	Timbre	Rythm	Stage presence
Actions ↓ \ weight→	4	3	2	5
Reine	7	5	3	8
Ismael	3	6	8	4
Moussa	6	8	4	3
Rene	5	4	6	7
Amie	2	3	7	5

Table 9. Decision-maker evaluation matrix 2. Bill

Criteria →	Accuracy of voice	Timbre	Rythm	Stage presence
Actions ↓ \ weight →	4	5	3	5
Reine	8	3	6	7
Ismael	6	5	7	3
Moussa	5	8	4	2
Rene	4	7	3	6
Amie	7	6	5	8

Table 10. Decision-maker evaluation matrix 3. Dèz

⊡ **VIKOR-METRIC solves the problem**

The calculation of the VIKOR indexes using formulas (10), (11), and (12) yields the following results:

Candidates	S_i	R_i	Q_i	Rank
$Reine$	6.000000	5.0	0.705479	3^{rd}
$Ismael$	7.800000	3.0	0.390411	2^{nd}
$Moussa$	7.600000	5.0	0.869863	5^{rd}
$Rene$	4.000000	3.0	0.000000	1^{st}
$Amie$	8.866667	4.0	0.750000	4^{th}

TABLE 11. Ranking of candidates by decision-maker 1 using the VIKOR method

Candidates	S_i	R_i	Q_i	Rank
$Reine$	3.8	2.0	0.000000	1^{st}
$Ismael$	8.4	4.0	0.681818	3^{rd}
$Moussa$	7.4	5.0	0.772727	4^{th}
$Rene$	5.8	2.4	0.218182	2^{nd}
$Amie$	10.4	4.0	0.833333	5^{th}

TABLE 12. Ranking of candidates by decision-maker 2 using the VIKOR method

Candidates	S_i	R_i	Q_i	Rank
$Reine$	6.583333	5.000000	0.681159	2^{nd}
$Ismael$	9.166667	4.166667	0.766908	3^{rd}
$Moussa$	10.250000	5.000000	1.000000	5^{th}
$Rene$	9.666667	4.000000	0.782609	4^{th}
$Amie$	4.500000	2.000000	0.000000	1^{st}

TABLE 13. Ranking of candidates by decision-maker 3 using the VIKOR method

This gives us the decision-maker ranking matrix M^t defined by the following table:

	1^{st}	2^{nd}	3^{rd}	4^{th}	5^{th}
Smarty	*Rene*	*Ismael*	*Rene*	*Amie*	*Moussa*
Bill	*Reine*	*Rene*	*Ismael*	*Moussa*	*Amie*
Dez	*Amie*	*Reine*	*Ismael*	*Rene*	*Moussa*

TABLE 14. Matrix of decision-maker rankings

By running the SRMP algorithm on this ranking table, we obtain the following results:

► $\delta_{BL} =$

48	52	36	48	32	36	60	64	32	52	28	40	56	68	44	64	32	36	60	64
48	60	44	48	52	56	40	52	36	40	72	76	36	56	32	44	68	80	48	68
36	40	72	76	52	64	48	52	64	68	44	56	40	44	76	80	40	60	36	48
72	84	60	80	40	44	76	80	64	76	52	56	68	72	56	68	44	48	80	84
52	72	40	52	76	88	64	84	44	48	80	84	68	80	64	68	72	76	60	72
56	60	84	88	56	76	52	64	80	92	68	88	56	60	84	88	72	84	68	72

► The minimum agreement is: 28.0

► Concensus storage is: [1 3 5 2 4]

This means that in consensual storage we have:

Reine	Ismael	Moussa	Rene	Amie
1^{st}	3^{rd}	5^{th}	2^{nd}	4^{th}

TABLE 15. Ranking of each candidate in the consensus ranking

4.3. **Exemple 3 (*selection of suppliers*).** This example is taken from [8]. We used triangular fuzzy aggregation operators (see [14]) to defuzzify the different matrices. A company operating in the automotive parts manufacturing sector aims to select a suitable partner among its suppliers to purchase key components for its new product.

After an initial screening, five candidate suppliers (S1, S2, S3, S4, and S5) remain under consideration. A committee composed of three decision-makers, D1, D2, and D3, was formed to select the most appropriate supplier. The following criteria were defined:

- Product quality (C_1)
- Adherence to delivery schedules (C_2)
- Price/cost (C_3)
- Supplier's technological level (C_4)

- Flexibility (C_5)

The importance or weight of the criteria and the scores assigned to the five suppliers by the three decision-makers according to the different criteria are given in the following tables:

Criteria	C_1	C_2	C_3	C_4	C_5
D_1	7	9	9	7	7
D_2	7	9	9	7	7
D_3	7	7	9	6	7

TABLE 16. Weight of criteria

Supplier	C1	C2	C3	C4	C5
S1	8	7	8	8	8
S2	8	9	3	8	8
S3	9	7	5	8	8
S4	8	8	7	8	8
S5	7	7	7	8	7

TABLE 17. D_1 evaluation matrix

Supplier	C1	C2	C3	C4	C5
S1	8	7	8	8	8
S2	8	9	5	9	8
S3	9	8	5	9	8
S4	8	7	8	8	8
S5	7	8	7	8	7

TABLE 18. D_2 evaluation matrix

Supplier	C1	C2	C3	C4	C5
S1	9	9	8	8	9
S2	8	8	3	8	8
S3	8	7	5	8	8
S4	8	8	8	5	8
S5	7	8	7	8	8

TABLE 19. D_3 evaluation matrix

By applying the different stages of the VIKOR method, we can summarise the different results in the following table:

decision-makers	**D1**				**D2**				**D3**			
Indexe	S	R	Q	Rank	S	R	Q	Rank	S	R	Q	Rank
S_1	0.42	0.23	0.52	2^{nd}	0.5	0.23	0.71	4^{th}	0.0	0.0	0.0	1^{st}
S_2	0.32	0.23	0.59	3^{rd}	0.32	0.23	0.5	1^{st}	0.64	0.25	1.0	5^{th}
S_3	0.37	0.23	0.65	4^{th}	0.35	0.23	0.53	3^{rd}	0.64	0.19	0.89	4^{th}
S_4	0.25	0.12	0.0	1^{st}	0.5	0.23	0.71	5^{th}	0.56	0.19	0.82	3^{rd}
S_5	0.64	0.23	1.0	5^{th}	0.73	0.17	0..5	2^{nd}	0.54	0.19	0.8	2^{nd}

TABLE 20. Results from the application of VIKOR

In this way, we obtain decision-maker rankings as defined in the following table:

	1^{st}	2^{nd}	3^{rd}	4^{th}	5^{th}
D_1	S_4	S_1	S_2	S_3	S_5
D_2	S_2	S_5	S_3	S_1	S_4
D_3	$S_!$	S_5	S_4	S_3	S_2

Table 21. Matrix of decision-maker rankings

Applying the SRMP algorithm to this table gives the following results:

► The minimum agreement is: 44.0

► Concensus storage is: [1 2 5 4 3]

This means that in consensual storage we have:

S_1	S_2	S_3	S_4	S_5
1^{st}	2^{nd}	5^{th}	4^{th}	3^{rd}

Table 22. Ranking of each supplier in the consensus ranking

The best supplier is therefore S_1.

4.4. Solving these three examples using the CHEMATRE method.

4.4.1. *Outline of the CHEMATRE method.* Proposed by Z. AVADOGO et al. [12], this method uses the weighted sum and the geometric mean. The aggregation is performed at two levels:

- **Aggregation at the decision-maker level:**

  Aggregation at this level consists of calculating the weighted sum of the alternatives' scores across the criteria:

$$G_k(a) = \sum_{j=1}^{j=m} w_j^k g_j^k(a), \quad \forall a \in A \tag{17}$$

  where

  - $G_k(a)$ is the overall score of alternative a according to decision-maker d_k;

  - w_j^k is the weight assigned to criterion j by decision-maker k;

  - $g_j^k(a)$ is the score given to alternative a on criterion j by decision-maker d_k.

- **Final aggregation across all decision-makers:**

  Each decision-maker k already has a global score $G_k(a)$ for each alternative a, so the next step is to compute the final value of each a. Due to its robustness, CHEMATRE suggests calculating, for each a, the geometric mean of the $G_k(a)$.

$$U(a) = \sqrt[s]{\prod_{k=1}^{s} G_k(a)}, \quad \forall a \in A \tag{18}$$

where

- $U(a)$ is the final numerical value of alternative a;

- $G_k(a)$ is the global value of alternative a according to decision-maker d_k.

After calculating the $U(a)$ values, they can be ranked according to the usual order of real numbers.

4.4.2. *Resolution.* **Didactic example**

By applying CHEMATRE to the didactic example, we obtain:

	$\sum_{j=1}^{j=4} w_j^1 g_j^1 (a_i)$	$\sum_{j=1}^{j=4} w_j^2 g_j^2 (a_i)$	$\sum_{j=1}^{j=4} w_j^3 g_j^3 (a_i)$	$\sqrt[3]{\prod_{k=1}^{k=3} G_k (a_i)}$	$Rank$
P_1	86	106	84	91.49	2^{nd}
P_2	78	100	96	90.81	3^{rd}
P_3	98	120	88	101.15	1^{st}
P_4	88	91	82	86.92	4^{th}

Table 23. Results of the didactic example given by the CHEMATRE method

We can see that Pesticide 3 is the best because it obtains the highest CHEMATRE score.

Example 2

Aggregating the evaluation matrices from example 2 gives the following results:

	$\sum_{j=1}^{j=4} w_j^1 g_j^1 (a_i)$	$\sum_{j=1}^{j=4} w_j^2 g_j^2 (a_i)$	$\sum_{j=1}^{j=4} w_j^3 g_j^3 (a_i)$	$\sqrt[3]{\prod_{k=1}^{k=3} G_k (a_i)}$	$Rank$
Reine	97	89	100	95.21	1^{st}
IsmaelS	85	66	85	78.12	5^{th}
Moussa	89	71	82	80.31	4^{th}
Rene	97	79	90	88.35	2^{nd}
Amie	82	56	113	80.35	3^{rd}

Table 24. Results of example 2 given by the CHEMATRE method

We can see that the best candidate is Reine because she has the highest CHEMATRE score.

Example 3

Aggregating the evaluation matrices from example 3 gives the following results:

	$\sum_{j=1}^{j=4} w_j^1 g_j^1 (a_i)$	$\sum_{j=1}^{j=4} w_j^2 g_j^2 (a_i)$	$\sum_{j=1}^{j=4} w_j^3 g_j^3 (a_i)$	$\sqrt[3]{\prod_{k=1}^{k=3} G_k (a_i)}$	*Rank*
S_1	303	303	309	304.99	1^{st}
S_2	276	301	243	272.29	5^{th}
S_3	283	299	254	278.03	4^{th}
S_4	303	303	270	291.57	2^{nd}
S_5	280	289	272	280.25	3^{rd}

Table 25. Results of example 3 given by the CHEMATRE method

We can see that the best supplier is S_1 because it obtains the highest CHEMATRE score.

4.5. **Comparison and discussion.** In summary, the rankings of the alternatives provided by the two methods for the three examples are presented in the following tables. These tables allow for a direct comparison of the results obtained by each method and for an assessment of their consistency across different contexts.

we denote by a_i the alternative i (with $i = 1, .., 5$).

Didactic example	a_1	a_2	a_3	a_4
VIKOPR-METRIC	1^{st}	2^{nd}	3^{rd}	4^{th}
CHEMATRE	1^{st}	2^{nd}	3^{rd}	4^{th}

Example 2	a_1	a_2	a_3	a_4	a_5
VIKOPR-METRIC	1^{st}	3^{rd}	5^{th}	2^{nd}	4^{th}
CHEMATRE	1^{st}	5^{th}	4^{th}	2^{nd}	3^{rd}

Example 3	a_1	a_2	a_3	a_4	a_5
VIKOPR-METRIC	1^{st}	2^{nd}	5^{th}	4^{th}	3^{rd}
CHEMATRE	1^{st}	5^{th}	4^{th}	2^{nd}	3^{rd}

Table 26. VIKOR-METRIC and CHEMATRE comparative tables for the three examples

The comparative analysis of the rankings obtained by the VIKOR-METRIC and CHEMATRE methods across these three examples highlights the relevance and superiority of the former. Developed as a hybridization of the VIKOR method and the Strict Ranking Metric Procedure [10], VIKOR-METRIC aims to reduce the compensatory effects often observed in classical multicriteria aggregation approaches, resulting in more consistent rankings.

In the first example, both methods converge to the same order, thus validating VIKOR-METRIC's ability to produce results aligned with expectations in didactic cases. In contrast, in examples 2 and 3, the CHEMATRE method exhibits counterintuitive inversions of alternatives, notably the unjustified degradation of alternative a_2.

By incorporating an appropriate distance measure, VIKOR-METRIC maintains a more stable hierarchy that better reflects balanced compromises. These results emphasize the advantage of this hybrid approach, which combines metric rigor with sensitivity to collective preferences, thereby providing a more robust and reliable tool for multicriteria decision-making.

5. Conclusion

In this article, we proposed VIKOR-METRIC, a novel group multicriteria decision-making (MCDM) method based on the hybridization of the VIKOR method and the Strict Ranking Metric Procedure (SRMP). Unlike classical approaches, which merely aggregate individual evaluation matrices into a single global matrix using compensatory operators, VIKOR-METRIC processes each viewpoint separately before seeking a consensus ranking that minimizes disagreements. This approach better preserves the diversity of decision-makers' preferences and limits the compensatory effects often observed in traditional methods.

The experimental results obtained across several examples show that the VIKOR-METRIC method provides more balanced rankings that more accurately reflect collective preferences, compared to existing methods such as CHEMATRE. VIKOR-METRIC thus represents a significant advancement in collective decision support, offering a solution that is both robust and nuanced for multicriteria analysis in group contexts.

Several interesting research directions can be envisioned. In particular, it would be relevant to explore the extension of VIKOR-METRIC to fuzzy or imprecise data to better model the uncertainties inherent in decision-makers' judgments. Furthermore, a deeper study of its mathematical properties, such as robustness, stability, and sensitivity to input changes, could strengthen its theoretical framework. Finally, applying this method to real-world cases (e.g., healthcare, energy, public policy) would enable broader empirical validation and facilitate its integration into practical decision-support tools.

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