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Developing a New MADM Method by Integrating SIR and VIKOR Methods

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Abstract

Multi criteria decision making methods (MADMs) are considered as the processes of determining the appropriate solution with established criteria where these criteria usually conflict with each other and there may be no solution satisfying all criteria simultaneously. There are a lot of processes introduced by researchers, but most of them did not take attention to compatibility of their methods for consistency with the most situations. The aim of this study is to introduce a new method that makes the process of problem solving easier. For constructing our method we used the concepts of SIR[1] and VIKOR[2] methods. The findings show that our proposed method is more simple, accurate and reliable than SIR method. The major contribution of our method is that it is compatible with most MADM problems because by two first steps of our method we can convert data of the problem into our pleasant and then compute the next steps of the problem.

Keywords: MADM, SIR, VIKOR, problem solving

[1] superiority and inferiority ranking method
[2] VlseKriterijumskaOptimizacija I KompromisnoResenje

1. Introduction

Multi criteria decision making methods are considered as the processes of determining the appropriate solution with established criteria where these criteria usually conflict with each other and there may be no solution satisfying all criteria simultaneously.

The aim of all researchers in this field is to find the simple and best process with high reliability and accuracy solution. According to ambiguity of real life, these processes usually did not appropriate for all problems solving. So the question rise up here that which method in MADM can be compatible with the most problem solving?

There are a lot of processes introduced by researchers, but most of them did not attention to compatibility of their method to consistency with the most situations. One of the main features of these methods is that they cannot deal with non-cardinal data and cardinal data as well. So the aim of this study is to introduce the method that makes the process of problem solving easier and compatible with the most situation.

The proposed method utilizes superiority and inferiority ranking (SIR) and VIKOR methods. This method is introduced for the first time by authors and is the first method that works in this manner. SIR method is based on the theory of fuzzy bags proposed by Rebai (1993, 1994). From SIR method we use six preference structures to obtain two superiority and inferiority matrixes.

Opricovic and Tzeng (2004) introduced the VIKOR method as a multi criteria decision making method to solve a discrete decision problem with non-commensurable and conflicting criteria. According to Opricovic and Tzeng (2004) this method focuses on ranking and selecting from a set of alternatives, and determines compromise solutions for a problem with conflicting criteria, which can help the decision makers to reach a final decision. In this method the final solution is the solution which is the closest to the ideal, and a compromise means an agreement established by mutual concessions.

According to VIKOR and two superiority and inferiority matrixes we compute one final solution for superiority matrix and one final solution for inferiority matrix. Then two solutions were compared for obtaining the final rank.

The paper is organized as follows. Section 2 is a brief description about previous work using SIR and VIKOR methods and definitions of SIR and VIKOR methods. In section 3 the proposed method is introduced. In section 4 the proposed method is illustrated with an example. Section 5 is concludes the paper and presents future research recommendations.

2. Literature Review

2.1. The SIR Method

SIR method, proposed by (Xu, 2001), is a generalization for the notations of superiority and inferiority scores defined by Rebai (1993, 1994) taking into consideration:

1. Differences between criteria values; and
2. Different types of generalized criterion.

Marzouk (2008) proposed a model for contractor selection. Contractor selection is a multiple criteria decision making wherein several criteria are required to be evaluated simultaneously. His proposed model utilizes superiority and inferiority ranking (SIR) method and it provides six preference structures in order to compare the performance of alternatives' criteria.

Tom and Tong (2008) propose a variant of superiority and inferiority ranking (SIR) method called SIR-Grey. They used this method for determining the location of large scale harbour-front project development. According to Tom and Tong (2008) this approach can overcome the problem encountered in using other methods which could lead to variation in the final ranking and hence an inconsistent result.

Chai and Liu (2010) proposed a novel intuitionistic fuzzy SIR method to solve the uncertainty group multi-criterion decision making problem. They applied the intuitionistic fuzzy sets to define the fuzzy natural language terms which are used to describe the individual decision values and the weights for criteria and for decision makers.

In SIR method we use such scores that these scores are obtained by comparing values of criteria. Assume that we have two alternatives A and A'. To calculate the scores for these ordinal data with respect to criterion g (to be maximized), we use the preference structure {P, I} as follows:

APA' (A is preferred to A') iff $g(A) > g(A')$

AIA' (A is indifferent to A') iff $g(A) = g(A')$

Where $g(A)$ and $g(A')$ are the criteria values for A and A' on criterion g.

First we must form a decision matrix. In any multi-criteria decision making method, the decision maker determines a number of criteria. Let $A_1, A_2, \ldots, A_m$ be m alternative and $(g_1, g_2, \ldots, g_n)$ be n cardinal criteria. $g_j(A_i)$ is the performance of the ith alternative A_i with respect to the jth criterion g_j. $g_j(.)$ Is a real-valued function $(i = 1,2,\ldots,m; j = 1,2,\ldots,n)$.

$$D \begin{bmatrix} g_1(A_1) & g_2(A_1) & \cdots & g_n(A_1) \\ g_1(A_2) & g_2(A_2) & \cdots & g_n(A_2) \\ & & & \\ g_1(A_m) & g_2(A_m) & \cdots & g_n(A_m) \end{bmatrix}$$

Then we weight each criterion. In this step we can use some method like AHP or Shannon entropy. Now we can compare the criteria value on each criterion(Xu, 2001).The generalized criterion is calculated using the elements of the decision matrix. The differences between criteria values are used to estimate the intensity of the preference of A over A' as per equation (1):

$$P(A, A') = f(d) = f(g(A) - g(A')) \quad (1)$$

$P(A, A')$ is the preference of A over A'.

Brans et al. (1986) proposed six generalized criterion types which can be used to capture the characteristics of functions that represent the specified criteria. According to the attitude towards the preference structure and intensity of preference, the decision maker selects the generalized criteria (along with its associated parameter). Table 1 lists the types of generalized criteria. It should be noted that the intensity of preference for Types 3, 5, and 6 changes gradually from 0 to 1.

Table 1: Generalized criteria

Criterion	Criterion	Criterion
Type 1: True Criterion $f(d) = \begin{cases} 1 & \text{if} \quad d \ge 0 \\ 0 & \text{if} \quad d < 0 \end{cases}$	**Type 2: Quasi Criterion** $f(d) = \begin{cases} 1 & \text{if} \quad d \ge q \\ 0 & \text{if} \quad d < q \end{cases}$	**Type 3: Criterion with Linear Preference** $f(d) = \begin{cases} 1 & \text{if} \quad d \ge p \\ \frac{d}{p} & \text{if} \quad 0 < d \le p \\ 0 & \text{if} \quad d \le 0 \end{cases}$
Type 4: Level Criterion $f(d) = \begin{cases} 1 & \text{if} \quad d \ge p \\ \frac{1}{2} & \text{if} \quad q < d \le p \\ 0 & \text{if} \quad d \le q \end{cases}$	**Type 5: Criterion with Linear Preference and Indifference Area** $f(d) = \begin{cases} 1 & \text{if} \quad d \ge p \\ \frac{d - q}{p - q} & \text{if} \quad q < d \le \\ 0 & \text{if} \quad d \le q \end{cases}$	**Type 6: Gaussian Criterion** $f(d) = \begin{cases} 1 - e^{\left(\frac{-d^2}{\sigma^2}\right)} & \text{if} \quad d \ge \\ 0 & \text{if} \quad d < \end{cases}$

For each alternative A_i, the superiority index $S_j(A_i)$ and inferiority index $I_j(A_i)$ with respect to the jth criterion are calculated as follows:

$$S_j(A_i) = \sum_{k=1}^{m} P(A_i, A_k) = \sum_{k=1}^{m} f_j(g_j(A_i) - g_j(A_k)) \tag{2}$$

$$I_j(A_i) = \sum_{k=1}^{m} P(A_k, A_i) = \sum_{k=1}^{m} f_j(g_j(A_k) - g_j(A_i)) \tag{3}$$

The superiority and inferiority indexes are used to form superiority matrix (S-matrix) and inferiority matrix (I-matrix). S-matrix provides information about the intensity of superiority of each alternative on each criterion, whereas, I-matrix provides information about the intensity of inferiority:

The superiority matrix (S-matrix)

$$S \begin{bmatrix} S_1(A_1) & S_2(A_1) & \cdots. & S_n(A_1) \\ S_1(A_2) & S_2(A_2) & \cdots & S_n(A_2) \\ & & & \\ S_1(A_m) & S_2(A_m) & \cdots & S_n(A_m) \end{bmatrix}$$

The inferiority matrix (I-matrix)

$$I \begin{bmatrix} I_1(A_1) & I_2(A_1) & \cdots. & I_n(A_1) \\ I_1(A_2) & I_2(A_2) & \cdots & I_n(A_2) \\ & & & \\ I_1(A_m) & I_2(A_m) & \cdots & I_n(A_m) \end{bmatrix}$$

The superiority and inferiority indexes (arranged in S- and I-matrix, respectively) are aggregated into two types of global preference indexes: superiority flow (S-flow) $\varphi^{\succ}(.)$ and inferiority flow (I-flow) $\varphi^{\prec}(.)$. The S- and I-flows are basically the intensity of each alternative. The former flow measures how an alternative is globally superior to (or outranks) all the others, whereas, the latter flow measures how an alternative is globally inferior to (or outranked by) all the others.

There are two aggregation procedures which are used to obtain S- and I-flows. These are SAW and TOPSIS procedures. The SAW is considered the simplest and clearest procedure. It is usually used as a benchmark to compare the results obtained from other procedures. The TOPSIS is considered very logical way of approaching the discrete MCDM problems. However, it is computationally more complex than SAW (Janic & Reggiani, 2002). The following sub-sections describe the structures of SAW and TOPSIS procedures. SAW procedure. S- and I-flows are calculated based on the weight of criteria (w_j) as follows:

$$\varphi^{\succ}(A_i) = \sum_{j=1}^{n} w_j S_j(A_i) \tag{4}$$

$$\varphi^{\prec}(A_i) = \sum_{j=1}^{n} w_j I_j(A_i) \tag{5}$$

Where $\sum_{j=1}^{n} w_j = 1 (w_j \geq 0)$.

TOPSIS procedure; S-flow is calculated based on ideal solution A_S^{+} and negative-ideal solution A_S^{-} for the superiority matrix (S-matrix) as follows:

$$\varphi^{\succ}(A_i) = \frac{S_i^-(A_i)}{S_i^-(A_i) - S_i^+(A_i)} \tag{6}$$

$$S_i^+(A_i) = \left\{ \sum_{j=1}^{n} \left| w_j (S_j(A_i) - S_j^+) \right|^{\lambda} \right\}^{1/\lambda} (0 \le \lambda \le \infty) \tag{7}$$

$$S_i^-(A_i) = \left\{ \sum_{j=1}^{n} \left| w_j (S_j(A_i) - S_j^-) \right|^{\lambda} \right\}^{1/\lambda} (0 \le \lambda \le \infty) \tag{8}$$

$$A_s^+ = (\max_i S_1(A_i), ..., \max_i S_n(A_i)) = (S_1^+, ..., S_n^+) \tag{9}$$

$$A_s^- = (\min_i S_1(A_i), ..., \min_i S_n(A_i)) = (S_1^-, ..., S_n^-) \tag{10}$$

I-flow is calculated based on ideal solution A_I^+ and negative-ideal solution A_I^- for the inferiority matrix (I-matrix) as follows:

$$\varphi^{\prec}(A_i) = \frac{I_i^+(A_i)}{I_i^-(A_i) - I_i^+(A_i)} \tag{11}$$

$$I_i^+(A_i) = \left\{ \sum_{j=1}^{n} \left| w_j (I_j(A_i) - I_j^+) \right|^{\lambda} \right\}^{1/\lambda} (0 \le \lambda \le \infty) \tag{12}$$

$$I_i^-(A_i) = \left\{ \sum_{j=1}^{n} \left| w_j (I_j(A_i) - I_j^-) \right|^{\lambda} \right\}^{1/\lambda} (0 \le \lambda \le \infty) \tag{13}$$

$$A_I^+ = (\min_i I_1(A_i), ..., \min_i I_n(A_i)) = (I_1^+, ..., I_n^+) \tag{14}$$

$$A_I^- = (\max_i I_1(A_i), ..., \max_i I_n(A_i)) = (I_1^-, ..., I_n^-) \tag{15}$$

Net and relative flows; Net flow (n-flow) and relative flows (r-flow) are calculated utilizing S- and I-flows as per equations (8) and (9):

$$\varphi_n(A_i) = \varphi^{\succ}(A_i) - \varphi^{\prec}(A_i) \tag{16}$$

$$\varphi r(A_i) = \frac{\varphi^{\succ}(A_i)}{(\varphi^{\succ}(A_i) - \varphi^{\prec}(A_i))} \tag{17}$$

Four complete ranking are obtained from S-, I-, n- and r-flows. These are S-ranking $(\Re_{>})$, I-ranking $(\Re_{<})$, n-ranking $(\Re_n)$, and r-ranking $(\Re_r)$. The S-ranking $\Re_{>} = \{P_{>}, I_{>}\}$, is obtained based on the descending order of $\varphi^{\succ}(A_i)$ as follows:

$$A_i P > A_k \text{ iff } \varphi^{\succ}(A_i) > \varphi^{\succ}(A_k) \tag{18}$$

$$A_i I > A_k \text{ iff } \varphi^{\succ}(A_i) > \varphi^{\prec}(A_k) \tag{19}$$

The I-ranking $\Re_{<} = \{P_{<}, I_{<}\}$, obtained based on the ascending order of $\varphi^{\prec}(A_i)$ as follows:

$$A_i P < A_k \text{ iff } \varphi^{\prec}(A_i) > \varphi^{\prec}(A_k) \tag{20}$$

$$A_i I < A_k \text{ iff } \varphi^{\prec}(A_i) = \varphi^{\prec}(A_k) \tag{21}$$

The n-ranking and r-ranking are obtained based on the descending order of n- and r-flows, respectively.

Partial ranking $(\Re)$ is obtained by combining S-ranking $\Re_{>}$, and I-ranking $\Re_{<}$, in a partial ranking structure as follows:

$$\Re = \{P, I, R\} = \Re_{>} \cap \Re_{<} \tag{22}$$

The intersection principle, proposed by Brans et al. (1986) and Roy et al. (1992), is adopted to compare any two alternatives as follows:

Preference relation P:

$$APA' \text{ iff } (AP > A' and AP < A') \text{ or } (AP < A' and AI > A') \text{ or } (AI > A' and AP < A') \tag{23}$$

Indifference relation I:

$$AIA' \text{ iff } AI > A' \text{ and } AI < A' \tag{24}$$

Incomparability relation R:

$$ARA' \text{ iff } (AP > A' and A'P < A) \text{ or } (A'P < A and AP > A') \tag{25}$$

2.1. VIKOR Method

Opricovic (1998), Opricovic and Tzeng (2002) developed VIKOR, the Serbian name: VlseKriterijumskaOptimizacija I KompromisnoResenje, means multi-criteria optimization and compromise solution (Chu, Shyu, Tzeng, & Khosla, 2007). The VIKOR method was developed for multi-criteria optimization of complex systems (Opricovic, S.; Tzeng, G.-H., 2004). Similar to some other MCDM methods like TOPSIS, VIKOR relies on an aggregating function that represents closeness to the ideal, but the unlike TOPSIS, introduces the ranking index based on the particular measure of closeness to the ideal solution and this method uses linear normalization to eliminate units of criterion functions (Opricovic, S.; Tzeng, G.-H., 2004).

Opricovic and Tzeng (2004) compared VIKOR and TOPSIS methods. These two MCDM method are both based on an aggregating function representing‘ ‘closeness to the ideal’’. According to their study, the normalized value in the VIKOR method does not depend on the evaluation unit of a criterion function, whereas the normalized values by vector normalization in the TOPSIS method may depend on the evaluation unit and the VIKOR method of compromise ranking determines a compromise solution, providing a maximum ‘‘group utility’’ for the ‘‘majority’’ and a minimum of an individual regret for the ‘‘opponent’’.

Tong, Chen and Wang (2007) developed a systematic procedure that involved applying the MCDM compromise ranking method VIKOR to optimize the multi-response process.

Sanayei, Mousavi and Yazdankhah (2010) proposed a hierarchy MCDM model based on fuzzy sets theory and VIKOR todeal with the supplier selection problems in the supply chain system.

Shemshadi, Shirazi,ToreihiandTarokh(2011) used fuzzy VIKOR method for supplier selection based on entropy measure for objective weighting.

Bazzazi, Osanloo and Karimi (2011) applied modified VIKOR method to Derive preference order of open pit mines equipment.

Kaya and Kahraman (2011) proposed an integrated VIKOR–AHP method to make a selection among the alternative forestation areas in Istanbul.

An MCDM problem can be expressed using a decision matrix as follows:

$$D = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \end{array}$$

Where x_{ij} is the rating of the ith alternative with respect to jth criterion.

The VIKOR method includes the following steps:

Step1. Determine the normalized decision matrix.
The normalized decision matrix can be expressed as follows:

$$F = \lfloor F_{ij} \rfloor_{m\times n} \tag{26}$$

Where $f_{ij} = \dfrac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}$, $i = 1,2,...,m;\ j = 1,2,...,n$ and x_{ij} is the performance of alternative A_i with respect to the jth criterion.

Step 2.Determine the best value (BV, f_j^*) and worst value (WV, f_j^-) of all criterion functions:

$$f_j^* = \left\{ ((\max f_{ij} \middle| j \in J) or (\min f_{ij} \middle| j \in J^{'}) \middle| i = 1,2,...,m) \right\} = \left\{ f_1^*, f_2^*, ..., f_n^* \right\} \tag{27}$$

$$f_j^- = \left\{ ((\min f_{ij} \middle| j \in J) or (\max f_{ij} \middle| j \in J^{'}) \middle| i = 1,2,...,m) \right\} = \left\{ f_1^-, f_2^-, ..., f_n^- \right\} \tag{28}$$

Where $J = \left\{ (j = 1,2,...,n \middle| f_j^*) \right\}$, a larger response is desired and
$J^{'} = \left\{ (j = 1,2,...,n \middle| f_{ij}) \right\}$, a smaller response is desired.

Step 3. The values $\dfrac{W_j (f_j^* - f_j^*)}{(f_j^* - f_j^-)}$ and R_i are computed in order to obtain:

$$S_j = \sum_{j=1}^{n} \frac{W_j (f_j^* - f_j^*)}{(f_j^* - f_j^-)} \tag{29}$$

$$R_j = \max_j \left[\frac{W_j (f_j^* - f_j^*)}{(f_j^* - f_j^-)} \right] \tag{30}$$

Where S_j refers to the separation measure of A_i from the best value, and R_j to the separation measure of A_i from the worst value.

Step 4.In the next step S^*, S^-, R^*, R^- and Q_i values are calculated:

$S^* = \min_i S_i$, $S^- = \max_i S_i$, $R^* = \min_i R_i$, $R^- = \max_i R_i$

The index $\min_i S_i$ and $\min_i R_i$ are related to a maximum majority rule, and a minimum individual regret of an opponent strategy, respectively. As well, v is introduced as weight of the strategy of the maximum group utility, usually v is assumed to be 0.5.

Step 5: Determine the final rank.

$$Q_i = v\left[\frac{S_i - S^*}{S^- - S^*} \right] + (1-v)\left[\frac{R_i - R^*}{R^- - R^*} \right] \tag{31}$$

Next task is the calculating Q_i and ranking the alternatives by the index Q_i. Finally, the best alternative with the minimum of Q_i is determined.

3. The Proposed Method

The two first steps in this method are similar to the twofirst steps in SIR method. First we formed a decision matrix.

Step 1: According to SIR method $A_1, A_2, ..., A_m$ are the alternatives and $g_1, g_2, ..., g_n$ are the criteria and $g_j(A_i)$ is the value of ith alternative with respect to jth criteria.

$$D\begin{bmatrix} g_1(A_1) & g_2(A_1) & \cdots. & g_n(A_1) \\ g_1(A_2) & g_2(A_2) & \cdots & g_n(A_2) \\ \\ g_1(A_m) & g_2(A_m) & \cdots & g_n(A_m) \end{bmatrix}$$

Step 2: According to SIR method and six generalized criteria types (see table 1), for each alternative A_i, the superiority index $S_j(A_i)$ and inferiority index $I_j(A_i)$ withrespect to the jth criterion are calculated as equations 32 and 33.

$$S_j(A_i) = \sum_{k=1}^{m} P(A_i, A_k) = \sum_{k=1}^{m} f_j(g_j(A_i) - g_j(A_k)) \tag{32}$$

$$I_j(A_i) = \sum_{k=1}^{m} P(A_k, A_i) = \sum_{k=1}^{m} f_j(g_j(A_k) - g_j(A_i)) \tag{33}$$

The superiority and inferiority indexes are used to form superiority matrix (S-matrix) and inferiority matrix (I-matrix).

The superiority matrix (S-matrix)

$$S\begin{bmatrix} S_1(A_1) & S_2(A_1) & \cdots. & S_n(A_1) \\ S_1(A_2) & S_2(A_2) & \cdots & S_n(A_2) \\ \\ S_1(A_m) & S_2(A_m) & \cdots & S_n(A_m) \end{bmatrix}$$

The inferiority matrix (I-matrix)

$$I\begin{bmatrix} I_1(A_1) & I_2(A_1) & \cdots. & I_n(A_1) \\ I_1(A_2) & I_2(A_2) & \cdots & I_n(A_2) \\ \\ I_1(A_m) & I_2(A_m) & \cdots & I_n(A_m) \end{bmatrix}$$

Step 3: Determine the best value (BV, f_j^*) and worst value (WV, f_j^-) of all criteria functions for each matrix as equations 34 and 35.

For S matrix: $S_j^+ = (\max_i S_1(A_i),...,\max_i(S_n(A_i)) = (S_1^+,...,S_n^+)$ and $S_j^- = (\min_i S_1(A_i),...,\min_i S_n(A_i)) = (S_1^-,...,S_n^-)$.

$$SS_j = \sum_{j=1}^{n} \frac{w_j(S_j^+ - S_j(A_i))}{(S_j^+ - S_j^-)} \tag{34}$$

$$RS_j = \max_j \left[\frac{w_j(S_j^+ - S_j(A_i))}{(S_j^+ - S_j^-)} \right] \tag{35}$$

for I matrix:

$I_j^+ = (\min_i I_1(A_i),...,\min_i(I_n(A_i)) = (I_1^+,...,I_n^+)$ and

$I_j^- = (\max_i I_1(A_i),...,\max_i I_n(A_i)) = (I_1^-,...,I_n^-)$.

$$SI_j = \sum_{j=1}^{n} \frac{w_j(I_j^+ - I_j(A_i))}{(I_j^+ - I_j^-)} \tag{36}$$

$$RI_j = \max_j \left[\frac{w_j (I_j^+ - I_j(A_i))}{(I_j^+ - I_j^-)} \right]$$

Step 4: In this step S^*, S^-, R^*, R^- values are calculated for each matrix:

For S-matrix:

$SS^* = \min_i S_i$, $SS^- = \max_i S_i$, $RS^* = \min_i R_i$, $RS^- = \max_i R_i$

For I matrix:

$SI^* = \min_i S_i$, $SI^- = \max_i S_i$, $RI^* = \min_i R_i$, $RI^- = \max_i R_i$

Step 5: Calculating Q_i and ranking the alternatives by the index Q_i for each matrix as equations 38 and 39.

For S-matrix

$$QS_i = v\left[\frac{SS_i - SS^*}{SS^- - SS^*}\right] + (1-v)\left[\frac{RS_i - RS^*}{RS^- - RS^*}\right] \quad (38)$$

For I-matrix

$$QI_i = v\left[\frac{SI_i - SI^*}{SI^- - SI^*}\right] + (1-v)\left[\frac{RI_i - RI^*}{RI^- - RI^*}\right] \quad (39)$$

According to the concepts of VIKOR method the best alternative is that with the minimum of Q_i for each matrix.

Step 6: Compare the ranking of each matrix and determine the final rank.

4. Numerical Example: Comparing the Results of the Proposed Method and SIR Method (Marzouk, 2008)

4.1. Results of the Proposed Method

In this section for examining our proposed method, we analyze the contractor selection problem of Marzouk(2008) and compare it with results of his paper that was obtained by SIR method.

According to Mazrouk (2008) the contractor selection problem is as follow:

The example considers a project in which the owner estimated cost is $6.5 million. Eight potential contractors (A, B, C, D, E, F, G, and H) have been prequalified in order to award the contract to one of them. The example assumes that seven criteria are deemed important to be evaluated. Table 2 lists the eight contractors and their respective criteria values.

Table 2: Criteria values for the eight contractors

Criteria / Alternatives	Capital bid	Financial stability	Length of time in industry	Management organization	Experience of technical personnel	Safety program	Past failed contracts
unit	**Million($)**	**per cent**	**Years**	**per cent**	**#**	**per cent**	**#**
A	6.8	70	12	72	9	78	2
B	6.6	71	8	77	19	81	0
C	6.1	71	11	92	11	78	4
D	6.2	88	19	69	7	81	3
E	6.8	87	11	90	24	84	1
F	6.2	77	5	86	10	87	4
G	6.3	71	18	93	9	86	3
H	6.6	76	20	86	25	88	1

The criteria objective and the selected generalized criteria are listed in Table 3.

Table 3: Characteristics of the selected criteria

Criterion	C_1	C_2	C_3	C_4	C_5	C_6	C_7
Preferred limit	**min**	**max**	**max**	**max**	**max**	**max**	**min**
Type of criterion	Type 2	Type 3	Type 5	Type 4	Type 1	Type 6	Type 1
Parameters	$q = 0.2$	$p = 20$	$q = 1.2\ (p = 12$	$q = 5\ (p = 30)$	-	$\sigma = 8$	-
Weight	0.45	0.15	0.07	0.1	0.1	0.07	0.06

Step 1: According to our proposed method we first construct the decision matrix. The numbers in this matrix are the value of each alternative (contractor) with respect to each criterion. The decision matrix (D) is as table 4.

Table 4: Decision matrix (D)

Criteria / alternatives	C_1	C_2	C_3	C_4	C_5	C_6	C_7
A	6.8	70	12	72	9	78	2
B	6.6	71	8	77	19	81	0
C	6.1	71	11	92	11	78	4
D	6.2	88	19	69	7	81	3
E	6.8	87	11	90	24	84	1
F	6.2	77	5	86	10	87	4
G	6.3	71	18	93	9	86	3
H	6.6	76	20	86	25	88	1

Step 2: In this step we calculate the superiority and inferiority of each alternative with respect to each criterion according to preferred generalized criterion type (see table 1) to construct superiority and inferiority matrixes.

The S matrix and I matrix are as table 5 and 6 respectably.

Table 5: S-matrix (S)

Criteria / Alternatives	C_1	C_2	C_3	C_4	C_5	C_6	C_7
A	0	0	0.769	0	1	0	4
B	2	0.05	0.167	0.5	5	0.136	7
C	5	0.05	0.611	2.5	4	0	0
D	4	4.65	3.704	0	0	0.136	2
E	0	4.3	0.611	1.5		0.626	5
F	4	1.3	0	1.5	3	1.504	0
G	4	0.05	3.33	2.5	1	1.173	2
H	2	1.05	4.148	1.5	7	1.877	5

Table 6: I-matrix (I)

Criteria / Alternatives	C_1	C_2	C_3	C_4	C_5	C_6	C_7
A	6	2.55	1.611	2.5	5	1.785	3
B	4	2.2	3.315	2.5	2	0.809	0
C	0	2.2	1.889	0	3	1.785	6
D	0	0	0	3	7	0.809	4
E	6	0.05	1.889	0	1	0.216	1
F	0	1.05	4.593	1	4	0.088	6
G	1	2.2	0.074	0	5	0.039	4
H	4	1.2	0	1	0	0	1

Step 3: The best value (BV, f_j^*) and worst value (WV, f_j^-) of all criteria functions for each matrix is determined as table 7 and 8 respectably.

Table 7: (BV, f_j^*) and worst value (WV, f_j^-) for S-matrix (S)

Criteria / B & W values	C_1	C_2	C_3	C_4	C_5	C_6	C_7
f^*	5	4.65	4.148	2.5	7	1.877	7
f^-	0	0	0	0	0	0	0
W	0.45	0.15	0.07	0.1	0.1	0.07	0.06

Table 8: (BV, f_j^*) and worst value (WV, f_j^-) for I-matrix (I)

Criteria / B & W values	C_1	C_2	C_3	C_4	C_5	C_6	C_7
f^*	0	0	0	0	0	0	0
f^-	6	2.55	4.593	3	7	1.785	6
W	0.45	0.15	0.07	0.1	0.1	0.07	0.06

Step 4: in this step we determine the value of SS and RS for Superiority matrix (see table 9).

Table 9: The values of SS, RS

Results	SS	RS
A	0.938451	0.45
B	0.659068	0.27
C	0.380933	0.148387
D	0.405278	0.1
E	0.724776	0.45
F	0.439118	0.108065
G	0.407017	0.148387
H	0.443272	0.27

With the same procedure the value of SI and RI is determined as table 10.

Table 10: The values of SI, RI

Rank	SI	RI
A	0.879314	0.45
B	0.623565	0.3
C	0.331058	0.129412
D	0.271725	0.1
E	0.514487	0.45
F	0.285692	0.07
G	0.318498	0.129412
H	0.413922	0.3

Step 5: in this step we determine the value of Q_s and Q_i for each matrix (see table 11):

Table 11: The values of Qs and Qi

Results	Qs	Qi
A	1	1
B	0.492298	0.592169
C	0.069124	0.127
D	0.021833	0.039474
E	0.80837	0.699774
F	0.063703	0.011493
G	0.092518	0.116663
H	0.298764	0.419648

For S rank the best rank for alternative is based on descending flow with consideration of SS and RS (the concepts of VIKOR method) (see table 12).

Table 12: S rank for S-matrix

SS	RS	QS	S rank
C	**D**	**D**	**D**
D	**F**	**F**	**F**
G	**C**	**C**	**C**
F	**G**	**G**	**G**
H	**H**	**H**	**H**
B	**B**	**B**	**B**
E	**E**	**E**	**E**
A	**A**	**A**	**A**

With the same procedure I rank is calculated as see in table 13.

Table 13: I rank for I-matrix

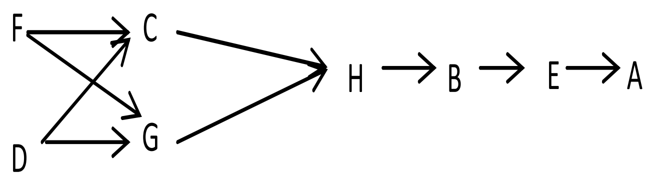
SI	RI	QI	I Rank
D	**F**	**F**	**F**
F	**D**	**D**	**D**
G	**G**	**G**	**G**
C	**C**	**C**	**C**
H	**H**	**H**	**H**
E	**B**	**B**	**B**
B	**E**	**E**	**E**
A	**A**	**A**	**A**

Step 6: in this step we compare the results of S rank and I rank (see table 14). The final rank for this problem is as figure 1.

Table 14: Final S and I rank

S rank	I rank
D	**F**
F	**D**
C	**G**
G	**C**
H	**H**
B	**B**
E	**E**
A	**A**

Figure 1:



4.2. Results of Marzouk (2008)

Marzouk (2008) in his paper calculated four flows with respect to TOPSIS procedure and three λ to rank the alternatives. The results of four flows with λ=1, 2 and 10 is as table 15.

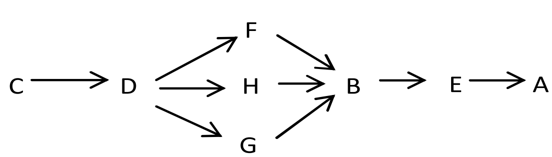
Table 15: The results of four flows in SIR.TOPSIS

SIR.TOPSIS	S flow	I flow	n flow	r flow
λ=1	0.084	0.869	-0.785	0.088
	0.401	0.587	-0.186	0.406
	0.622	0.255	0.367	0.709
	0.609	0.265	0.344	0.697
	0.376	0.617	-0.241	0.379
	0.538	0.274	0.264	0.663
	0.547	0.313	0.234	0.636
	0.555	0.438	0.117	0.559
λ=2	0.097	0.89	-0.793	0.098
	0.415	0.63	-0.215	0.397
	0.717	0.179	0.538	0.8
	0.678	0.226	0.452	0.75
	0.294	0.76	-0.466	0.279
	0.662	0.193	0.469	0.774
	0.634	0.254	0.38	0.714
	0.459	0.59	-0.131	0.438
λ=10	0.096	0.924	-0.828	0.094
	0.4	0.667	-0.267	0.375
	0.765	0.123	0.642	0.861
	0.72	0.206	0.514	0.778
	0.23	0.818	-0.588	0.219
	0.774	0.133	0.641	0.853
	0.718	0.187	0.531	0.793
	0.402	0.665	-0.263	0.377

The results of four flows were compared to obtain the final rank. The procedure of final rank in this manner is as follow:

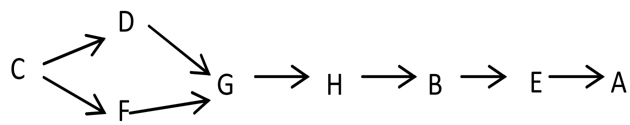
For λ=1

Figure 2:



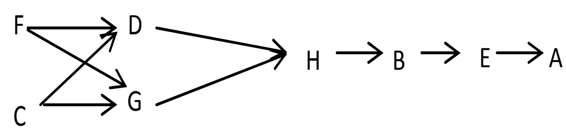
For λ=2

Figure 3:



For λ=10

Figure 4:



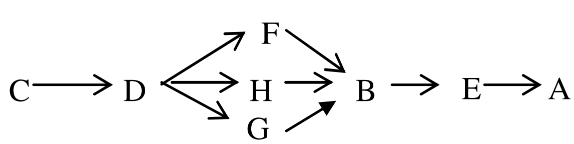
Another result in Marzouk (2008) was obtained by SAW procedure. In this procedure Marzouk calculated four flows that are seen in table 16.

Table 16: The results of four flows in SIR.SAW

SIR.SAW	S flow	I flow	n flow	r flow
	0.396	4.25	-3.854	0.085
	1.899	2.869	-0.97	0.398
	2.96	1.247	1.703	0.7
	2.886	1.297	1.589	0.69
	1.782	3.015	-1.233	0.371
	1.782	1.34	1.21	0.656
	2.593	1.528	1.066	0.629
	2.629	2.14	0.561	0.551

According to results of SIR.SAW in table 16 the ranking of alternatives is as follow:

Figure 5:



4.3. Comparing the Results of Proposed Method and Marzouk (2008)

Comparing our result with Marzouk (2008) result, shows that our result is near to ranking result that was obtained by $\lambda = 10$ in Marzouk's paper.

Marzouk in his paper used two aggregative procedures to obtain superiority and inferiority flows. The first aggregative procedure was SAW and the second was TOPSIS. SAW is a simple procedure that is not time consuming and the results were obtained quickly, but it is not accuracy procedure.

Despite SAW procedure TOPSIS is an accurate procedure, but it is time consuming and complex procedure. According to marzouk (2008), the results show that there is a difference between the rankings of two aggregative procedures. Another problem is that in TOPSIS procedure we must consider different λvalues to obtain the reliable results. The major problem of SIR method is that the decision maker must compute four flows and then compare the results of these flows to obtain the complete ranking.

5. Conclusion and Future Research

In this paper we proposed a method that is a combination of SIR and VIKOR methods. The major value of our proposed method is that it is compatible with most MADM problems because by two first steps of our method we can convert data of the problem in our pleasant and then compute the problem next steps. Despite SIR method, our proposed method is not complex and time consuming. We eliminate some steps in SIR method. Despite SIR method it is not needed to consider different values for λ. furthermore in our proposed method it is not needed to compute four flows. The steps in our method are more simple and fewer than SIR method. With comparing our method result by Marzouk's paper result, it shows that our proposed method is more accurate and reliable than SIR method.

For future researches we can combine other MADM methods like AHP, TOPSIS, ELECTREs, … with SIR. The two first steps in our method can be stable in all methods and other steps can be changeable. So we can test these methods and then find that which of these methods are reliable, simple and accurate.

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