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A New Group Decision Model Based on Grey-Intuitionistic Fuzzy-ELECTRE and VIKOR for Contractor Assessment Problem

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Abstract: This study introduces a new decision model with multi-criteria analysis by a group of decision makers (DMs) with intuitionistic fuzzy sets (IFSs). The presented model depends on a new integration of IFSs theory, ELECTRE and VIKOR along with grey relational analysis (GRA). To portray uncertain real-life situations and take account of complex decision problem, multi-criteria group decision-making (MCGDM) model by totally unknown importance are introduced with IF-setting. Hence, a weighting method depended on Entropy and IFSs, is developed to present the weights of DMs and evaluation factors. A new ranking approach is provided for prioritizing the alternatives. To indicate the applicability of the presented new decision model, an industrial application for assessing contractors in the construction industry is given and discussed from the recent literature.

Keywords: multi-criteria group decision-making; ELECTRE; VIKOR; IFSs; GRA; contractor assessment problem

1. Introduction

The contractor selection process (CSP) includes five main stages in practice as follows [1]:

- Project packaging;
- Invitation;
- Prequalification;
- Shortlisting;
- Bid evaluation.

Multi-criteria decision-making (MCDM) approach can be suitable in solving complex problems, such as executing system selection and contractor evaluation [2–4]. The CSP can be taken in the MCDM framework, considering an overall strategy [5–7]. Different criteria must be considered along with the interest of a group of experts or decision makers (DMs) [8]. For the CSP, analytical methods have not properly improved, despite a high increase in the multifaceted nature of projects along with a relative increase in candidate forms of executing systems for the projects. Hence, these decision tools and methods should be highlighted and employed [9].

The outranking methods, as an uncommon category of MCDM methods, meet the particular requirements of the soft decisions which properly handle the real-decision situations e.g., [10–13]. To start with outranking method, ELECTRE (ELimination and Choice Expressing the Reality) was created by Roy [14]. Some outranking approaches, based on ELECTRE as well-known model, were reported in recent years i.e., [15,16]. Hashemi et al. [17] utilized the interval-valued intuitionistic fuzzy (IVF)-ELECTRE III as a suitable choice, keeping in mind the end goal to illuminate an investment project selection problem. Azadnia et al. [18] used the fuzzy C-Means (FCM) clustering regarded as a data-mining approach to categorize suppliers, and ELECTRE has been utilized to rank the suppliers. Sevkli [19] compared and contrasted crisp and fuzzy ELECTRE approaches for the supplier evaluation in an industry case. Teixeira de Almeida [20] proposed a model that integrated ELECTRE and utility function regarding to outsourcing contracts appraisement. Montazer et al. [21] developed a fuzzy expert system that was utilized to assist firms with fuzzy ELECTRE III. Marzouk [22] regarded MCDM approach with ELECTRE III for the CSP. You et al. [23] extended MCDM approach based on ELECTRE III and best-worst techniques with the multiplicative preference relations and intuitionistic fuzzy sets (IFSs).

Classical MCDM methods assume that the ratings of alternatives and the evaluation factors' relative importance regarded ascertain numbers, but in real engineering applications and management situations, these assumptions are not practical [24]. Therefore, various types of membership functions by concentrating on ambiguous components have been applied in solving engineering and management problems [25–30]. The IFSs propose a generalization of fuzzy sets theory [31,32]. Recently, this theory regards the explicit presentation and expression with both likes and dislikes. Various scientists have displayed new approaches and methodologies to adapt to the fuzzy MCDM (FMCDM) issues with taking IFSs. Chen [33] developed an IFS-approach to the problem solving, by utilizing decision tree induction. Ye [34] regarded decision problems by unknown information on weights of criteria with Entropy and IFSs. Li et al. [35] provided a linear programming approach for handling the MCDM with DMs and IFSs. Liu [36] extended power-average operator with IFSs for dealing with the MCDM. Fouladgar et al. [37] proposed a model to regard a specific end goal to figure the importance weights of assessment components and to rank feasible projects, respectively. Hashemi et al. [38] developed a compromise ratio approach with IFSs theory to water resources area. Zhao et al. [39] reported an IFS-VIKOR method to handle the supplier selection. Hosseinzadeh et al. [40] designed an MCDM model with a combination of IFS, grey relational analysis (GRA) and TOPSIS method to select the best precursor. Zavadskas et al. [41] extended the MULTIMOORA approach with IVIFSs for analyzing real-world civil engineering problems. Keshavaraz Ghorabaee et al. [42] reported the compromise solution by T2FSs for project selection problem.

This study designs a new multi-criteria group decision-making (MCGDM) model in light of novel hybrid approaches of the GRA, IF-ELECTRE and VIKOR along with multi-criteria analysis. In the IF-ELECTRE method, the calculation process of concordance dominance (CD) and discordance dominance (DD) matrixes are in light of the idea that the potential candidate or alternative ought to have the most limited distance from the positive ideal solution (PIS) and farthest distance from the negative ideal solution (NIS). Further, a weighting approach is regarded and extended in view of a generalized version of the Entropy and IFSs to determine weights of both DMs and the criteria. Finally, in view of the idea of the VIKOR method, a new index is introduced for appraising the alternatives.

The rest of this study is arranged as follows. An overview of IFSs is reported in Section 2. A decision model is illustrated in Section 3. A real application example is presented for the contractor selection problem according to the literature in Section 4 to indicate the steps of the model. In the final section, conclusions will be given.

2. Preliminaries

Atanassov [31] developed traditional fuzzy set to the IFS with regard to a hesitation degree. An IF is defined as:

$$I = \{\chi, \mu_I(\chi), v_I(\chi) | \chi \in X\}, \tag{1}$$

which is described with a membership function μ_I and a non-membership function v_I, where

$$\mu_I : \chi \to [0,1], \chi \in X \to \mu_A(\chi) \in [0,1], \tag{2}$$

$$v_I : \chi \to [0,1], \chi \in X \to v_A(\chi) \in [0,1] \tag{3}$$

with the condition

$$0 \le \mu_I(\chi) + v_I(\chi) \le 1 \; for \; all \; \chi \in X. \tag{4}$$

The third parameter of IFS is $\pi_I(\chi)$, regarded as the intuitionistic fuzzy index as below [43]:

$$\pi_I(\chi) = 1 - \mu_I(\chi) - v_I(\chi). \tag{5}$$

and

$$0 \le \pi_I(\chi) \le 1. \tag{6}$$

Definition 1 [31,44]**.** Let I and I' be two IFSs, then

$$I \bigoplus I' = \{\chi, \mu_I(\chi) + v_{I'}(\chi) - \mu_I(\chi).\mu_{I'}(\chi), v_I(\chi).v_{I'}(\chi) | \chi \in X\}, \tag{7}$$

$$I \bigotimes I' = \{\chi, \mu_I(\chi).\mu_{I'}(\chi), v_I(\chi) + v_{I'}(\chi) - v_I(\chi).v_{I'}(\chi) | \chi \in X\}. \tag{8}$$

From these Equations, the following relations are obtained:

$$nI = \{\chi, (1 - (1 - \mu_I(\chi))^n, (v_I(\chi))^n | \chi \in X\}, n \ge 0, \tag{9}$$

$$I^n = \{\chi, (\mu_I(\chi))^n, (1 - (1 - v_I(\chi))^n, | \chi \in X\}, n \ge 0. \tag{10}$$

Definitionn 2 [45,46]**.** Let I be an IFS. Then the score function S and the accuracy function H may be represented as below:

$$S(I) = \mu_I - v_I, \tag{11}$$

and

$$H(I) = \mu_I - v_I, \tag{12}$$

respectively. Clearly $S(I) \in [-1,1]$ and $H(I) \in [0,1]$ for any IFS I.

Definitionn 3 [47]**.** Intuitionistic fuzzy weighted geometric with respect to a weighting vector ω, $IFWG_\omega$ is characterized as

$$IFWG_\omega(I_1, I_2, \ldots, I_n) = \prod_{j=1}^{n} I_j^{\omega_j} = \langle \prod_{j=1}^{n} \left(\mu_{I_j}\right)^{\omega_j}, 1 - \prod_{j=1}^{n} (1 - v_{Ij})^{\omega_j} \rangle, \tag{13}$$

where $\omega_k \in [0,1]$, and $\sum_{j=1}^{n} \omega_j = 1, (j = 1, 2, \ldots, n)$.

Definitionn 4 [48]. Distance between two IFSs I and I' can be characterized as takes after:

$$D(I,I') = \sqrt{\frac{1}{2n}\sum_{j=1}^{n}\left[(\mu_I(\chi_j) - \mu_{I'}(\chi_j))^2 + (v_I(\chi_j) - v_{I'}(\chi_j))^2 + (\pi_I(\chi_j) - \pi_{I'}(\chi_j))^2\right]} \tag{14}$$

3. Proposed Uncertain Group Decision Model

For the MCGDM problem with IF uncertainty, let $CA = \{CA_1, CA_2, \ldots, CA_\mathrm{m}\}$ be a set of m candidates or alternatives, and $CR = \{CR_1, CR_2, \ldots, CR_\mathrm{n}\}$ be the set of n conflicting criteria, and let $DM = \{DM_1, DM_2, \ldots, DM_\mathrm{t}\}$ be a set of t DMs. Let $X^{(e)} = \left(\tilde{x}_{ij}^{(e)}\right)_{m\times n}$ be an IF-decision matrix, where $\tilde{x}_{ij}^{(e)} = \left(\mu_{ij}^{(e)}, v_{ij}^{(e)}, \pi_{ij}^{(e)}\right)$ is a criterion value provided by eth DM, denoted by an IFN, for the alternative CA_i versus the criterion CR_j.

The process of the proposed group decision model based on GRA, IF-ELECTRE and VIKOR methods are provided as below.

3.1. Determine the DMs' Importance, Criteria' Weights and Aggregated IFS Decision Matrix

There are various tools and approaches to regard the criteria' weights. This study adopts information regarding Entropy method to provide criteria' weights. The Entropy was one of the ideas in thermodynamics originally by Shannon [49]. The steps of determining the DMs' importance and criteria' weights by Entropy method are reported as below:

(1) To denote the DMs' importance from the IF-decision matrix, the method of Entropy weights [50] is given by:

$$\lambda_{ij}^{(e)} = \frac{1 - J_{ij}^{(e)}}{t - \sum_{k=1}^{t} J_{ij}^{(e)}}, \tag{15}$$

where $\lambda_{ij}^{(e)} \in [0,1], \sum_{e=1}^{t}\lambda_{ij}^{(e)} = 1, i = 1, 2, \ldots, m, j = 1, 2, \ldots, n, e = 1, 2, \ldots, t$ and $J_{ij}^{(e)}$ is computed by:

$$J_{ij}^{(e)} = \frac{1}{\sqrt{2}-1} \times \left\{\sin\frac{\pi\left(1+\mu_{ij}^{(e)} - v_{ij}^{(e)}\right)}{4} + \sin\frac{\pi\left(1-\mu_{ij}^{(e)} + v_{ij}^{(e)}\right)}{4} - 1\right\}, \tag{16}$$

where $0 \le J_{ij}^{(e)} \le 1, i = 1,2,\ldots,m, j = 1,2,\ldots,n$ and $e = 1,2,\ldots,t$.

(2) After weights' values for the DMs are obtained, the evaluating values described by different DMs are aggregated regarding the IFWG operator by:

$$\tilde{r}_{ij} = \left(\tilde{x}_{ij}^{(1)}\right)^{\lambda_{ij}^{(1)}} \bigotimes \left(\tilde{x}_{ij}^{(2)}\right)^{\lambda_{ij}^{(2)}} \bigotimes \ldots \bigotimes \left(\tilde{x}_{ij}^{(t)}\right)^{\lambda_{ij}^{(t)}}, \tag{17}$$

$$\tilde{r}_{ij} = \langle \mu_{ij}, v_{ij}\rangle = \langle \prod_{e=1}^{t}\left(\mu_{ij}^{(e)}\right)^{\lambda_{ij}^{(e)}}, 1 - \prod_{e=1}^{t}\left(1 - v_{ij}^{(e)}\right)^{\lambda_{ij}^{(e)}} \rangle. \tag{18}$$

(3) To provide w_j as weights of evaluation criteria, IF-Entropy is as below [50]:

$$G_j = \frac{1}{m}\sum_{i=1}^{m}\frac{1}{\sqrt{2}-1}\left(\sin\frac{\pi(1+\mu_{ij} - v_{ij})}{4} + \sin\frac{\pi(1-\mu_{ij}+v_{ij})}{4} - 1\right), \tag{19}$$

where $0 \le G_j \le 1,\ i = 1,2,\ldots,m$ and $j = 1,2,\ldots,n$.

Entropy weight of the jth criterion is reported as:

$$w_j = \frac{1 - G_j}{n - \sum_{j=1}^{n} G_j}, \tag{20}$$

where $w_j \in [0, 1]$, $\sum\limits_{j=1}^{n} w_j = 1$, $j = 1, 2, \ldots, n$.

3.2. Ranking of Alternatives by the Model

We can consider different alternatives and compare based on their IF values. Various types of concordance sets as the concordance set, midrange concordance set, and weak concordance set (CS) by ideas of score function and accuracy function are classified. It is also similar to discordance set (DS) [13].

Let $\widetilde{X} = (\mu_{\widetilde{x}}, v_{\widetilde{x}}, \pi_{\widetilde{x}})$ be an IF value. The CS C_{kl} of A_k and A_l contains all criteria for which A_k is preferred to A_l. We apply ideas of score function, accuracy function, and hesitancy degree of the IFNs to classify concordance sets. The CS C_{kl} can be provided as follows [13]:

$$C^1_{kl} = \left\{ j \middle| \mu_{kj} > \mu_{lj}\ ,\ v_{kj} < v_{lj}\ and \left(\mu_{kj} + v_{kj}\right) > \left(\mu_{lj} + v_{lj}\right) \right\} \tag{21}$$

where $j = 1, 2, \ldots, n$, and Equation (21) can be more concordant than Equation (22) or Equation (23).

The midrange CS C^2_{kl} is denoted:

$$C^2_{kl} = \left\{ j \middle| \mu_{kj} > \mu_{lj}\ ,\ v_{kj} < v_{lj}\ \text{and} \left(\mu_{kj} + v_{kj}\right) \leq \left(\mu_{lj} + v_{lj}\right) \right\} \tag{22}$$

The main difference between Equations (21) and (22) is the hesitancy degree; it at the kth alternative versus the jth criterion is regarded higher than the lth alternative versus the jth criterion in the midrange concordance set. Thus, Equation (21) can be more concordant than (22).

The weak CS C^3_{kl} is denoted as:

$$C^3_{kl} = \left\{ j \middle| \mu_{kj} \geq\ \mu_{lj}\ and\ v_{kj} \geq\ v_{lj} \right\} \tag{23}$$

The degree of non-membership at the kth alternative versus the jth criterion is regarded higher than the lth alternative versus the jth criterion in weak concordance set; thus, Equation (22) can be more concordant than (23).

The DS includes all criteria for which A_k is not related to A_l by:

$$D^1_{kl} = \left\{ j \middle| \mu_{kj} < \mu_{lj}\ ,\ v_{kj} \geq\ v_{lj}\,\text{and} \left(\mu_{kj} + v_{kj}\right) \leq \left(\mu_{lj} + v_{lj}\right) \right\} \tag{24}$$

The midrange DS D^2_{kl} is denoted as follows:

$$D^2_{kl} = \left\{ j \middle| \mu_{kj} \left\langle \mu_{lj}\ ,\ v_{kj} \right\rangle v_{lj}\ \text{and} \left(\mu_{kj} + v_{kj}\right) > \left(\mu_{lj} + v_{lj}\right) \right\} \tag{25}$$

Equation (24) can be more discordant than Equation (25).

The weak DS D^3_{kl} is denoted as follows:

$$D^3_{kl} = \left\{ j \middle| \mu_{kj} < \mu_{lj}\ and\ v_{kj} < v_{lj} \right\} \tag{26}$$

Equation (25) can be more discordant than Equation (26).

In the proposed new hybrid GRA, IF-ELECTRE and VIKOR model with assessment data, the relative value of CS could be taken through the concordance index. Hence, the concordance index C_{kl} between A_k and A_l in this study is characterized as:

$$\varphi_{kl} = w_{c^1} \times \sum_{j \in C^1_{kl}} w_j + w_{c^2} \times \sum_{j \in C^2_{kl}} w_j + w_{c^3} \times \sum_{j \in C^3_{kl}} w_j, \tag{27}$$

where w_{c^1}, w_{c^2} and w_{c^3} are the weights of the concordance, midrange concordance, and weak concordance sets, respectively, and w_j is the weight of the evaluation criteria.

Concordance matrix Φ could be formed as:

$$\Phi = \begin{bmatrix} - & \varphi_{12} & \varphi_{13} & \cdots & \varphi_{1m} \\ \varphi_{21} & - & \varphi_{23} & \cdots & \varphi_{2m} \\ \vdots & \vdots & - & \ddots & \vdots \\ \varphi_{(m-1)1} & \varphi_{(m-1)2} & \cdots & - & \varphi_{(m-1)m} \\ \varphi_{m1} & \varphi_{m2} & \cdots & \varphi_{m(m-1)} & - \end{bmatrix}, \tag{28}$$

where the maximum and the minimum values of φ_{kl} are denoted by φ^* and, φ^- which are the positive ideal point and negative ideal point, respectively. Also, a higher value of φ_{kl} indicates that A_k would be preferred to A_l and vice versa.

Evaluations of certain A_k are worse than appraisements of a competing A_k. Discordance index is provided as:

$$\varepsilon_{kl} = \frac{\max\limits_{j \in D_{kl}} w^*_D \times d\left(\widetilde{x}_{kj}, \widetilde{x}_{lj}\right)}{\max\limits_{j \in J} d\left(\widetilde{x}_{kj}, \widetilde{x}_{lj}\right)}, \tag{29}$$

where $d\left(\widetilde{x}_{kj}, \widetilde{x}_{lj}\right)$ is determined by Equation (14), and w^*_D is equal to w_{D^1}, w_{D^2} or w_{D^3}. Discordance matrix E is formed as:

$$E = \begin{bmatrix} - & \varepsilon_{12} & \varepsilon_{13} & \cdots & \varepsilon_{1m} \\ \varepsilon_{21} & - & \varepsilon_{23} & \cdots & \varepsilon_{2m} \\ \vdots & \vdots & - & \ddots & \vdots \\ \varepsilon_{(m-1)1} & \varepsilon_{(m-1)2} & \cdots & - & \varepsilon_{(m-1)m} \\ \varepsilon_{m1} & \varepsilon_{m2} & \cdots & \varepsilon_{m(m-1)} & - \end{bmatrix} \tag{30}$$

where the maximum and the minimum values of ε_{kl} are indicated with ε^* and ε^-, which are the negative ideal and positive ideal points, respectively. A higher value of ε_{kl} indicates that A_k would be less favourable than A_l and vice versa.

Steps of the GRA algorithm can be reported as below [51–54]: The grey relational coefficient is calculated. The grey relational coefficient $\gamma\left(x_{0j}, x_{ij}\right)$ is computed by:

$$\gamma\left(x_{0j}, x_{ij}\right) = \frac{\min\limits_i \min\limits_j \left|x_{0j} - x_{ij}\right| + \rho \max\limits_i \max\limits_j \left|x_{0j} - x_{ij}\right|}{\left|x_{0j} - x_{ij}\right| + \rho \max\limits_i \max\limits_j \left|x_{0j} - x_{ij}\right|}, \tag{31}$$

where ρ is the identification coefficient $\rho \in [0, 1]$, $i = 1, 2, \ldots, m$ and $j = 1, 2, \ldots, n$.

The grade $\gamma\left(x_{0j}, x_{ij}\right)$ between x_0 and x_i can be as:

$$\gamma(x_0, x_i) = \sum_{j=1}^{n} w_j \gamma\left(x_{0j}, x_{ij}\right) \text{ and } \sum_{j=1}^{n} w_j = 1, \tag{32}$$

Introduced CD matrix calculation process in this study is according to the compromise solution idea. It means that the alternative must have the shortest grey relational coefficient from PIS and the farthest grey relational coefficient from the NIS; thus, the CD matrix Ψ is formed as:

$$\Psi = \begin{bmatrix} - & \psi_{12} & \psi_{13} & \cdots & \psi_{1m} \\ \psi_{1m} & - & p_{23} & \cdots & \psi_{2m} \\ \vdots & \vdots & - & \ddots & \vdots \\ \psi_{(m-1)1} & \psi_{(m-1)2} & \cdots & - & \psi_{(m-1)m} \\ \psi_{m1} & \psi_{m2} & \cdots & \psi_{m(m-1)} & - \end{bmatrix} \tag{33}$$

where

$$\psi_{kl} = \frac{\xi_{kl}^{+}}{\xi_{kl}^{-} + \xi_{kl}^{+}}, \tag{34}$$

$$\xi_{kl}^{+} = \frac{\min\limits_{1 \le k \le m} \min\limits_{1 \le l \le m} |\varphi^{*} - \varphi_{kl}| + \rho \max\limits_{1 \le k \le m} \max\limits_{1 \le l \le m} |\varphi^{*} - \varphi_{kl}|}{|\varphi^{*} - \varphi_{kl}| + \rho \max\limits_{1 \le k \le m} \max\limits_{1 \le l \le m} |\varphi^{*} - \varphi_{kl}|}, \ k \text{ and } l = 1, 2, \ldots, m, \tag{35}$$

$$\xi_{kl}^{-} = \frac{\min\limits_{1 \le k \le m} \min\limits_{1 \le l \le m} |\varphi^{-} - \varphi_{kl}| + \rho \max\limits_{1 \le k \le m} \max\limits_{1 \le l \le m} |\varphi^{-} - \varphi_{kl}|}{|\varphi^{-} - \varphi_{kl}| + \rho \max\limits_{1 \le k \le m} \max\limits_{1 \le l \le m} |\varphi^{-} - \varphi_{kl}|}, \ k \text{ and } l = 1, 2, \ldots, m. \tag{36}$$

A higher value of ψ_{kl} could indicate that A_k is less favourable than A_l.

In a similar way, the presented DD matrix is formed in this study similar to the proposed CD matrix calculation process; thus, the DD matrix Ω is formed as:

$$\Omega = \begin{bmatrix} - & \omega_{12} & \omega_{13} & \cdots & \omega_{1m} \\ \omega_{1m} & - & p_{23} & \cdots & \omega_{2m} \\ \vdots & \vdots & - & \ddots & \vdots \\ \omega_{(m-1)1} & \omega_{(m-1)2} & \cdots & - & \omega_{(m-1)m} \\ \omega_{m1} & \omega_{m2} & \cdots & \omega_{m(m-1)} & - \end{bmatrix} \tag{37}$$

where

$$\omega_{kl} = \frac{\zeta_{kl}^{+}}{\zeta_{kl}^{-} + \zeta_{kl}^{+}}, \tag{38}$$

$$\zeta_{kl}^{+} = \frac{\min\limits_{1 \le k \le m} \min\limits_{1 \le l \le m} |\varepsilon^{*} - \varepsilon_{kl}| + \rho \max\limits_{1 \le k \le m} \max\limits_{1 \le l \le m} |\varepsilon^{*} - \varepsilon_{kl}|}{|\varepsilon^{*} - \varepsilon_{kl}| + \rho \max\limits_{1 \le k \le m} \max\limits_{1 \le l \le m} |\varepsilon^{*} - \varepsilon_{kl}|}, \ k \text{ and } l = 1, 2, \ldots, m, \tag{39}$$

$$\zeta_{kl}^{-} = \frac{\min\limits_{1 \le k \le m} \min\limits_{1 \le l \le m} |\varepsilon^{-} - \varepsilon_{kl}| + \rho \max\limits_{1 \le k \le m} \max\limits_{1 \le l \le m} |\varepsilon^{-} - \varepsilon_{kl}|}{|\varepsilon^{-} - \varepsilon_{kl}| + \rho \max\limits_{1 \le k \le m} \max\limits_{1 \le l \le m} |\varepsilon^{-} - \varepsilon_{kl}|}, \ k \text{ and } l = 1, 2, \ldots, m. \tag{40}$$

A higher value of ω_{kl} could indicate that A_k is preferred to A_l. According to the VIKOR method idea, the $\mathcal{I}_i$, $\mathcal{R}_i$, $\mathcal{I}_i'$ and $\mathcal{R}_i'$ values are represented by:

$$\mathcal{I}_i = \sum_{l=1; l \ne k}^{m} \psi_{il}, \tag{41}$$

$$\mathcal{R}_i = \max_{l}(\psi_{il}), \tag{42}$$

$$\mathcal{I}_i' = \sum_{l=1; l \ne k}^{m} \omega_{il}, \tag{43}$$

$$\mathcal{R}'_i = \max_l(\omega_{il}). \tag{44}$$

Then, the values of indices δ_i and ϱ_i are proposed:

$$\delta_i = \left(\frac{\mathcal{I}_i + \mathcal{R}_i}{2}\right)\left(\frac{\mathcal{I}_i - \mathcal{I}^+}{\mathcal{I}^- - \mathcal{I}^+}\right) + \left(\frac{2 - (\mathcal{I}_i + \mathcal{R}_i)}{2}\right)\left(\frac{\mathcal{R}_i - \mathcal{R}^+}{\mathcal{R}^- - \mathcal{R}^+}\right) \tag{45}$$

and

$$\varrho_i = \left(\frac{\mathcal{I}'_i + \mathcal{R}'_i}{2}\right)\left(\frac{\mathcal{I}'_i - \mathcal{I}'^-}{\mathcal{I}'^+ - \mathcal{I}'^-}\right) + \left(\frac{2 - (\mathcal{I}'_i + \mathcal{R}'_i)}{2}\right)\left(\frac{\mathcal{R}'_i - \mathcal{R}'^-}{\mathcal{R}'^+ - \mathcal{R}'^-}\right), \tag{46}$$

where $\begin{cases} \mathcal{I}^+ = \min_i \mathcal{I}_i \\ \mathcal{I}^- = \max_i \mathcal{I}_i \end{cases}, \begin{cases} \mathcal{R}^+ = \min_i \mathcal{R}_i \\ \mathcal{R}^- = \max_i \mathcal{R}_i \end{cases}, \begin{cases} \mathcal{I}'^+ = \max_i \mathcal{I}'_i \\ \mathcal{I}'^- = \min_i \mathcal{I}'_i \end{cases}, \begin{cases} \mathcal{R}'^+ = \max_i \mathcal{I}_i \\ \mathcal{R}'^- = \min_i \mathcal{I}_i \end{cases}.$

We have the following relation:

$$Q_i = \frac{\delta_i}{\delta_i + \varrho_i} \tag{47}$$

Q_i is the final value of assessment. All options can be positioned by Q_i. The best option A^* can be characterized as below:

$$A^* = \max\{Q_i\}. \tag{48}$$

3.3. Algorithm

An algorithm of the proposed decision model can be given as below:

- step 1. A group of DMs is established to solve the complicated decision problem by considering conflicting criteria;
- step 2. Proper criteria are reported for the selection problem;
- step 3. Provide the ratings of each candidate versus each selected criterion for each DM;
- step 4. Weight of each DM from the decision matrix is calculated by Equations (15) and (16);
- step 5. Construct an aggregated IFS decision matrix by Equations (17) and (18);
- step 6. Present the weights of appraisement criteria by Equations (19) and (20);
- step 7. Identify the CS and DS. Find C^1_{kl}, C^2_{kl}, C^3_{kl}, D^1_{kl}, D^2_{kl} and D^3_{kl} for pair-wise comparisons of candidates by Equations (21)–(26);
- step 8. Form the concordance matrix Φ by Equations (27) and (28);
- step 9. Calculate the discordance matrix E by Equations (29) and (30);
- step 10. Form CD matrix P by Equations (33)–(36);
- step 11. Form DD matrix O by Equations (37)–(40);
- step 12. Determine the values of $\mathcal{I}_i$, $\mathcal{R}_i$, $\mathcal{I}'_i$ and $\mathcal{R}'_i$ by Equations (41)–(44);
- step 13. Compute the values of indices δ_i and ϱ_i are by Equations (45) and (46);
- step 14. Calculate values of ranking index (Q_i) using Equation (47). Rank the candidates in decreasing order.

Finally, a flowchart of the proposed model is illustrated in Figure 1.

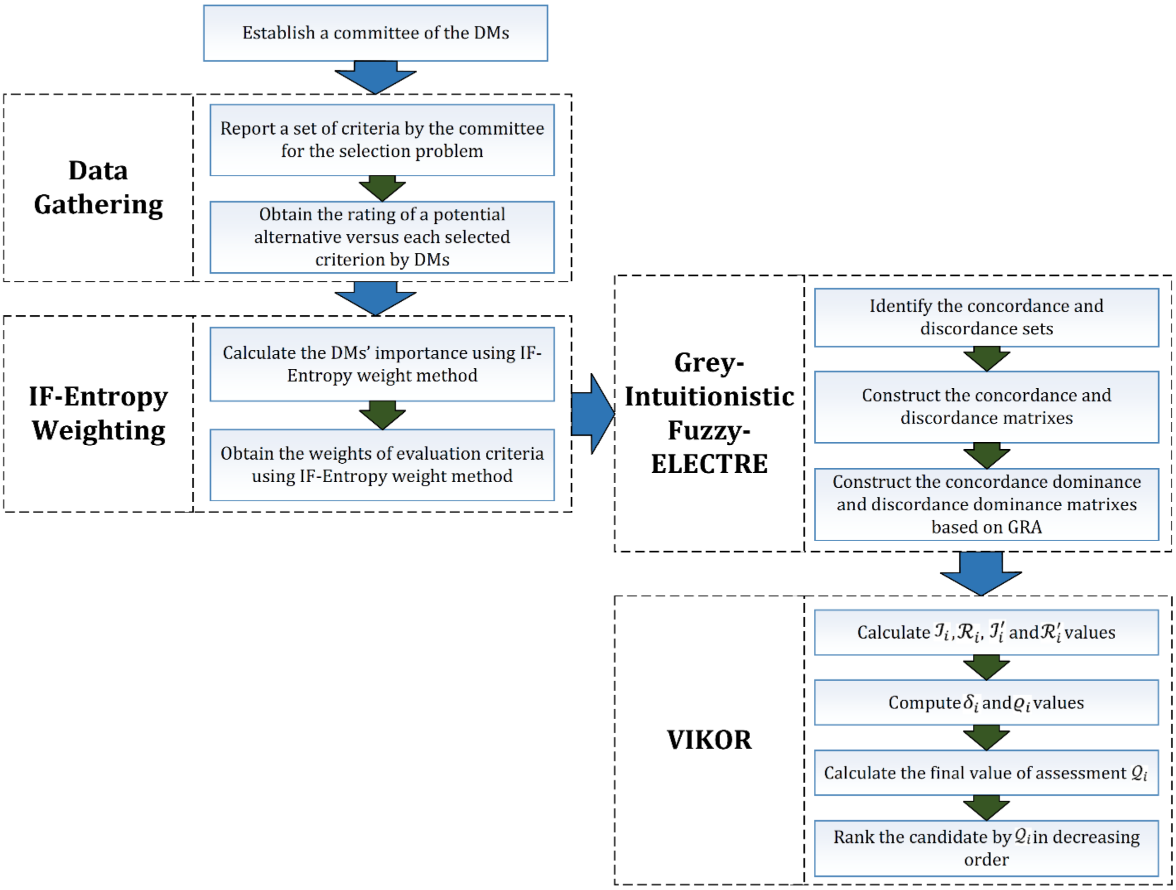

Figure 1. Flowchart of proposed model.

4. Solution of Contractor Assessment Problem

4.1. Implementation and Computational Results

Construction projects are initiated in dynamically changing and complicated environment, which result in circumstances of high uncertainty and risks [55,56]. Choosing the best alternative for a building is of great importance for owners, contractors, and stakeholders [57]. To exhibit the appropriateness of the soft decision model, a case study from the recent literature [58] is presented regarding the construction contractor assessment. This assessment can be via some conflicting criteria. A group of three DMs (DM_1, DM_2, and DM_3) is arranged to appraise the appropriate contractor. In this industrial application, five potential contractors (CO_1, CO_2, ..., CO_5) are chosen, and twenty criteria (CR_1, CR_2, ..., CR_{20}) . are reported for final assessments (steps 1 and 2). By taking DMs' judgments, all ratings of alternatives versus evaluation factors are represented with linguistic variables by Table 1.

Table 1. Linguistic variables for performance ratings.

Linguistic Variables	Intuitionistic Fuzzy Numbers
Verygood (VG)	$\langle 0.90, 0.10 \rangle$
Good (G)	$\langle 0.80, 0.15 \rangle$
Medium good (MG)	$\langle 0.65, 0.25 \rangle$
Fair (F)	$\langle 0.50, 0.40 \rangle$
Medium poor (MP)	$\langle 0.30, 0.60 \rangle$
Poor (P)	$\langle 0.20, 0.75 \rangle$
Verypoor (VP)	$\langle 0.10, 0.90 \rangle$

The performance of alternatives in terms of appraisement criteria is represented by three DMs and then illustrated in Table 2 (step 3).

Table 2. Ratings of contractors.

Criteria	Contractors	Decision Makers		
		DM_1	DM_2	DM_3
CR_1	CO_1	F	MP	MP
	CO_2	G	MG	VG
	CO_3	MP	F	F
	CO_4	MG	G	F
	CO_5	MG	F	F
CR_2	CO_1	F	MP	MP
	CO_2	VG	G	G
	CO_3	MG	G	G
	CO_4	G	MG	VG
	CO_5	MG	F	F
CR_3	CO_1	VG	VG	G
	CO_2	MG	G	G
	CO_3	G	VG	MG
	CO_4	MG	G	G
	CO_5	F	MP	MG
CR_4	CO_1	MP	F	F
	CO_2	G	MG	MG
	CO_3	F	MP	MG
	CO_4	G	VG	MG
	CO_5	MG	G	F
CR_5	CO_1	F	MG	MP
	CO_2	VG	G	G
	CO_3	MG	F	G
	CO_4	MG	F	G
	CO_5	MG	G	G
CR_6	CO_1	F	MG	MP
	CO_2	VG	VG	G
	CO_3	MG	F	F
	CO_4	G	VG	MG
	CO_5	G	VG	MG
CR_7	CO_1	MG	G	G
	CO_2	G	MG	VG
	CO_3	MG	F	F
	CO_4	G	MG	VG
	CO_5	G	MG	MG
CR_8	CO_1	F	MG	MP
	CO_2	MG	G	G
	CO_3	F	MG	MG
	CO_4	MG	F	F
	CO_5	MG	F	F
CR_9	CO_1	MG	G	F
	CO_2	VG	G	G
	CO_3	MG	G	F
	CO_4	G	MG	MG
	CO_5	MG	G	G
CR_{10}	CO_1	F	MG	MG
	CO_2	G	VG	VG
	CO_3	F	MG	MG
	CO_4	G	VG	MG
	CO_5	MG	F	G

Table 2. *Cont.*

Criteria	Contractors	Decision Makers		
		DM_1	DM_2	DM_3
CR_{11}	CO_1	MG	F	F
	CO_2	VG	G	G
	CO_3	MG	F	G
	CO_4	G	VG	MG
	CO_5	MG	F	G
CR_{12}	CO_1	F	MP	MP
	CO_2	MG	F	F
	CO_3	F	MG	MP
	CO_4	F	MP	MG
	CO_5	MG	G	F
CR_{13}	CO_1	MG	G	G
	CO_2	G	VG	VG
	CO_3	MG	F	G
	CO_4	G	VG	VG
	CO_5	G	MG	VG
CR_{14}	CO_1	MP	P	F
	CO_2	F	MG	MP
	CO_3	MP	F	P
	CO_4	F	MP	MP
	CO_5	F	MG	MP
CR_{15}	CO_1	MP	F	P
	CO_2	F	MG	MP
	CO_3	F	MP	MP
	CO_4	F	MP	MP
	CO_5	F	MG	MG
CR_{16}	CO_1	F	MP	MP
	CO_2	MG	F	G
	CO_3	F	MP	MG
	CO_4	MG	F	F
	CO_5	F	MP	MP
CR_{17}	CO_1	F	MG	MG
	CO_2	MG	F	F
	CO_3	MG	G	F
	CO_4	MG	G	G
	CO_5	F	MG	MG
CR_{18}	CO_1	MG	G	G
	CO_2	VG	VG	G
	CO_3	G	MG	VG
	CO_4	G	VG	MG
	CO_5	MG	G	F
CR_{19}	CO_1	F	MP	MP
	CO_2	G	VG	VG
	CO_3	MG	F	G
	CO_4	G	MG	VG
	CO_5	MG	F	F
CR_{20}	CO_1	MG	F	G
	CO_2	G	VG	MG
	CO_3	MG	G	F
	CO_4	G	VG	MG
	CO_5	G	VG	MG

Table 1 Linguistic variables for performance ratings.

The weights of each DM are computed and presented by Equations (15) and (16) and then by Equations (17) and (18), the aggregated IFS decision matrix constructs by the DMs (steps 4 and 5), reported in Table 3.

Table 3. Aggregated IFS decision matrix.

Contractors \ Criteria	CR_1	CR_2	CR_3	CR_4
CO_1	⟨0.308, 0.591⟩	⟨0.308, 0.591⟩	⟨0.874, 0.113⟩	⟨0.329, 0.569⟩
CO_2	⟨0.827, 0.139⟩	⟨0.841, 0.129⟩	⟨0.774, 0.167⟩	⟨0.731, 0.195⟩
CO_3	⟨0.329, 0.569⟩	⟨0.774, 0.167⟩	⟨0.827, 0.139⟩	⟨0.492, 0.402⟩
CO_4	⟨0.750, 0.183⟩	⟨0.827, 0.139⟩	⟨0.774, 0.167⟩	⟨0.827, 0.139⟩
CO_5	⟨0.631, 0.268⟩	⟨0.631, 0.268⟩	⟨0.492, 0.402⟩	⟨0.750, 0.183⟩
Contractors \ Criteria	CR_5	CR_6	CR_7	CR_8
CO_2	⟨0.841, 0.129⟩	⟨0.874, 0.113⟩	⟨0.827, 0.139⟩	⟨0.774, 0.167⟩
CO_3	⟨0.750, 0.183⟩	⟨0.631, 0.268⟩	⟨0.631, 0.268⟩	⟨0.645, 0.255⟩
CO_4	⟨0.750, 0.183⟩	⟨0.827, 0.139⟩	⟨0.827, 0.139⟩	⟨0.631, 0.268⟩
CO_5	⟨0.774, 0.167⟩	⟨0.827, 0.139⟩	⟨0.731, 0.195⟩	⟨0.631, 0.268⟩
Contractors \ Criteria	CR_9	CR_{10}	CR_{11}	CR_{12}
CO_2	⟨0.841, 0.129⟩	⟨0.874, 0.113⟩	⟨0.841, 0.129⟩	⟨0.631, 0.268⟩
CO_3	⟨0.750, 0.183⟩	⟨0.645, 0.255⟩	⟨0.750, 0.183⟩	⟨0.492, 0.402⟩
CO_4	⟨0.731, 0.195⟩	⟨0.827, 0.139⟩	⟨0.827, 0.139⟩	⟨0.492, 0.402⟩
CO_5	⟨0.774, 0.167⟩	⟨0.750, 0.183⟩	⟨0.750, 0.183⟩	⟨0.750, 0.183⟩
Contractors \ Criteria	CR_{13}	CR_{14}	CR_{15}	CR_{16}
CO_2	⟨0.874, 0.113⟩	⟨0.492, 0.402⟩	⟨0.492, 0.402⟩	⟨0.750, 0.183⟩
CO_3	⟨0.750, 0.183⟩	⟨0.224, 0.716⟩	⟨0.308, 0.591⟩	⟨0.492, 0.402⟩
CO_4	⟨0.874, 0.113⟩	⟨0.308, 0.591⟩	⟨0.308, 0.591⟩	⟨0.631, 0.268⟩
CO_5	⟨0.827, 0.139⟩	⟨0.492, 0.402⟩	⟨0.645, 0.255⟩	⟨0.308, 0.591⟩
Contractors \ Criteria	CR_{17}	CR_{18}	CR_{19}	CR_{20}
CO_2	⟨0.631, 0.268⟩	⟨0.874, 0.113⟩	⟨0.874, 0.113⟩	⟨0.827, 0.139⟩
CO_3	⟨0.750, 0.183⟩	⟨0.827, 0.139⟩	⟨0.750, 0.183⟩	⟨0.750, 0.183⟩
CO_4	⟨0.774, 0.167⟩	⟨0.827, 0.139⟩	⟨0.827, 0.139⟩	⟨0.827, 0.139⟩
CO_5	⟨0.645, 0.255⟩	⟨0.750, 0.183⟩	⟨0.631, 0.268⟩	⟨0.827, 0.139⟩

Twenty criteria' weights are established with Equations (19) and (20) and are given in Table 4 (step 6).

Table 4. Aggregated IFS decision matrix by DMs' opinions.

Criteria	CR_1	CR_2	CR_3	CR_4	CR_5
Weights	0.038	0.055	0.063	0.041	0.058
Criteria	CR_6	CR_7	CR_8	CR_9	CR_{10}
Weights	0.059	0.061	0.028	0.064	0.059
Criteria	CR_{11}	CR_{12}	CR_{13}	CR_{14}	CR_{15}
Weights	0.062	0.020	0.082	0.021	0.020
Criteria	CR_{16}	CR_{17}	CR_{18}	CR_{19}	CR_{20}
Weights	0.022	0.040	0.078	0.056	0.073

The CS and DS could be identified (step 7). The relative weights of DMs also are reported as:

$$W' = [w_{C^1}, w_{C^2}, w_{C^3}, w_{D^1}, w_{D^2}, w_{D^3}] = \left[1, \frac{2}{3}, \frac{1}{3}, 1, \frac{2}{3}, \frac{1}{3}\right],$$

The CS can be:

$$C^1_{kl} = \begin{bmatrix} - & 3,17 & 3,7,13 & 3,9 & 3,7,18 \\ 1,2,4,5,6,7,8,9,10,11,12,13,16,18,19,20 & - & 1,2,4,5,6,7,8,9,10,11,12,13,16,18,19,20 & 1,2,5,6,8,9,10,11,12,16,18,19 & 1,2,3,5,6,7,8,9,10,11,13,16,18,19 \\ 2,5,6,8,11,17,18,19 & 3,17 & - & 3,8,9 & 2,3,8,17,18,19 \\ 1,2,4,5,6,7,8,10,11,13,16,17,18,19,20 & 4,17 & 1,2,4,6,7,10,11,13,16,17,19,20 & - & 1,2,3,4,7,10,11,13,16,17,18,19 \\ 1,2,4,5,6,8,9,10,11,12,13,19,20 & 4,12,15,17 & 1,4,5,6,7,9,10,12,13,15,20 & 5,9,12,15 & - \end{bmatrix}$$

The midrange CS can be:

$$C^2_{kl} = \begin{bmatrix} - & - & - & - & - \\ 14,15 & - & 14,15 & 14,15 & \\ 1,4,12,15,16 & - & - & - & 16 \\ 12,14,15 & - & 14 & - & \\ 14,15 & - & 14 & 14 & - \end{bmatrix}$$

The weak CS can be:

$$C^3_{kl} = \begin{bmatrix} - & - & 9,10,14,20 & - & 16,17 \\ - & - & - & 3,7,13,20 & 14,20 \\ 9,10,14,20 & - & - & 5,12,15 & 11 \\ - & 3,7,13,20 & 5,12,15,18 & - & 6,8,20 \\ 16,17 & 14,20 & 11 & 6,8,20 & - \end{bmatrix}$$

The DS can be:

$$D^1_{kl} = \begin{bmatrix} - & 1,2,4,5,6,7,8,9,10,11,12,13,16,18,19,20 & 2,5,6,8,11,17,18,19 & 1,2,4,5,6,7,8,10,11,13,16,17,18,19,20 & 1,2,4,5,6,8,9,10,11,12,13,19,20 \\ 3,17 & - & 3,17 & 4,17 & 4,12,15,17 \\ 3,7,13 & 1,2,4,5,6,7,8,9,10,11,12,13,16,18,19,20 & - & 1,2,4,6,7,10,11,13,16,17,18,19,20 & 1,4,5,6,7,9,10,12,13,15,20 \\ 3,9 & 1,2,5,6,8,9,10,11,12,16,18,19 & 3,8,9 & - & 5,9,12,15 \\ 3,7,18 & 1,2,3,5,6,7,8,9,10,11,13,16,18,19 & 2,3,8,17,18,19 & 1,2,3,4,7,10,11,13,16,17,18,19 & - \end{bmatrix}$$

The midrange DS can be:

$$D^2_{kl} = \begin{bmatrix} - & 14,15 & 1,4,12,15,16 & 12,14,15 & 14,15 \\ - & - & - & - & - \\ - & 14,15 & - & 14 & 14 \\ - & 14,15 & - & - & 14 \\ - & - & 16 & - & - \end{bmatrix}.$$

The weak DS can be:

$$D^3_{kl} = \begin{bmatrix} - & - & - & - & - \\ - & - & - & - & - \\ - & - & - & - & - \\ - & - & - & - & - \\ - & - & - & - & - \end{bmatrix}.$$

Then, matrixes of the concordance and discordance can be formed (steps 8 and 9). The respective results can be as:

$$\Phi = \begin{bmatrix} - & 0.241 & 1.069 & 0.241 & 0.694 \\ 3.711 & - & 3.711 & 3.322 & 2.921 \\ 2.922 & 0.241 & - & 1.058 & 1.100 \\ 3.614 & 0.827 & 3.332 & - & 2.636 \\ 3.401 & 1.503 & 2.934 & 1.631 & - \end{bmatrix},$$

$$\mathrm{E} = \begin{bmatrix} - & 1.000 & 1.000 & 1.000 & 0.963 \\ 0.165 & - & 0.226 & 0.681 & 0.352 \\ 0.285 & 1.000 & - & 1.000 & 1.000 \\ 0.178 & 0.731 & 0.115 & - & 1.000 \\ 0.780 & 1.000 & 0.909 & 0.960 & - \end{bmatrix}$$

Consequently, matrixes of the CD and DD are constructed (steps 10 and 11). The respective results are as follows:

$$\Psi = \begin{bmatrix} - & 0.250 & 0.369 & 0.250 & 0.315 \\ 0.750 & - & 0.750 & 0.694 & 0.636 \\ 0.636 & 0.250 & - & 0.368 & 0.374 \\ 0.736 & 0.334 & 0.695 & - & 0.595 \\ 0.705 & 0.432 & 0.638 & 0.450 & - \end{bmatrix}$$

and

$$\Omega = \begin{bmatrix} - & 0.750 & 0.750 & 0.750 & 0.729 \\ 0.278 & - & 0.313 & 0.570 & 0.384 \\ 0.346 & 0.750 & - & 0.750 & 0.750 \\ 0.285 & 0.598 & 0.250 & - & 0.750 \\ 0.626 & 0.750 & 0.698 & 0.727 & - \end{bmatrix}$$

$\mathcal{I}_i$, $\mathcal{R}_i$, $\mathcal{I}'_i$ and $\mathcal{R}'_i$ values are determined (step 12).

$$\mathcal{I} = \begin{bmatrix} 0.296 \\ 0.708 \\ 0.407 \\ 0.590 \\ 0.556 \end{bmatrix}, \mathcal{R} = \begin{bmatrix} 0.369 \\ 0.750 \\ 0.636 \\ 0.736 \\ 0.705 \end{bmatrix}, \mathcal{I}' = \begin{bmatrix} 0.745 \\ 0.386 \\ 0.390 \\ 0.471 \\ 0.700 \end{bmatrix}, \text{ and} \mathcal{R}' = \begin{bmatrix} 0.750 \\ 0.570 \\ 0.750 \\ 0.750 \\ 0.750 \end{bmatrix}.$$

Then, the values of indices δ_i and ϱ_i are computed (step 13).

$$\delta = \begin{bmatrix} 0.000 \\ 1.000 \\ 0.479 \\ 0.812 \\ 0.736 \end{bmatrix}, \text{ and } \varrho = \begin{bmatrix} 0.000 \\ 1.000 \\ 0.831 \\ 0.562 \\ 0.919 \end{bmatrix}.$$

Finally, the final value of evaluation index (Q_i) s calculated (step 14) as given in Table 5. The optimal ranking order is as $CO_2 > CO_4 > CO_5 > CO_3 > CO_1$ and the best contractors could be the CO_2. In addition, the final value of evaluation index Q_i for appraising alternatives has been taken in comparison with the fuzzy VIKOR method by the previous study [58] in Table 5. The results demonstrate that the same ranking results on the CSP are obtained.

Table 5. Final value of Q_i for ranking order of alternatives.

Contractors	Q_i	Final Ranking (Proposed Model)	Final Ranking (Fuzzy VIKOR by [58])
CO_1	0.000	5	5
CO_2	1.000	1	1
CO_3	0.369	4	4
CO_4	0.599	2	2
CO_5	0.443	3	3

The computational results are given in Table 5; the proposed model (via the GRA, Entropy, IFSs, ELECTRE and new compromise ranking index) versus the modified VIKOR method (via conventional fuzzy sets) by the previous study [58] is compared. Both models can handle complex CSPs with uncertain conditions; however, some main merits of the presented group decision model are provided as below:

- Firstly, this study takes account of key advantages of IFSs and GRA concurrently to handle the uncertain information via the group decision process and to involve more flexibility to illustrate the imprecise and vague data of the several experience DMs.
- Secondly, a new ranking method based on the compromise solution within a new version of classical ELECTRE approach is developed to distinguish potential candidates of the complex CSP as a reasonable way of the optimal ranking, and to introduce stable decisions in the construction industry with uncertain conditions.

4.2. Sensitivity Analysis

A sensitivity analysis is represented on each identification coefficient value ρ. The computational results can be represented in Table 6 and illustrated in Figure 2. According to Table 6, the final ranking orders of contractors with the changes of ρ value (ρ = 0.1 to ρ = 1) are the same.

Table 6. Sensitivity analysis on each identification coefficient value.

ρ Value		Contractors				
		CO_1	CO_2	CO_3	CO_4	CO_5
ρ = 0.1	Q_i Preference order ranking	0.000 5	1.000 1	0.377 4	0.618 2	0.441 3
ρ = 0.2	Qi Preference order ranking	0.000 5	1.000 1	0.374 4	0.611 2	0.442 3
ρ = 0.3	Qi Preference order ranking	0.000 5	1.000 1	0.372 4	0.606 2	0.442 3
ρ = 0.4	Qi Preference order ranking	0.000 5	1.000 1	0.370 4	0.602 2	0.443 3
ρ = 0.5	Qi Preference order ranking	0.000 5	1.000 1	0.369 4	0.599 2	0.443 3
ρ = 0.6	Qi Preference order ranking	0.000 5	1.000 1	0.368 4	0.597 2	0.444 3
ρ = 0.7	Qi Preference order ranking	0.000 5	1.000 1	0.368 4	0.595 2	0.444 3
ρ = 0.8	Qi Preference order ranking	0.000 5	1.000 1	0.367 4	0.594 2	0.444 3
ρ = 0.9	Qi Preference order ranking	0.000 5	1.000 1	0.366 4	0.592 2	0.444 3
ρ = 1	Qi Preference order ranking	0.000 5	1.000 1	0.366 4	0.591 2	0.445 3

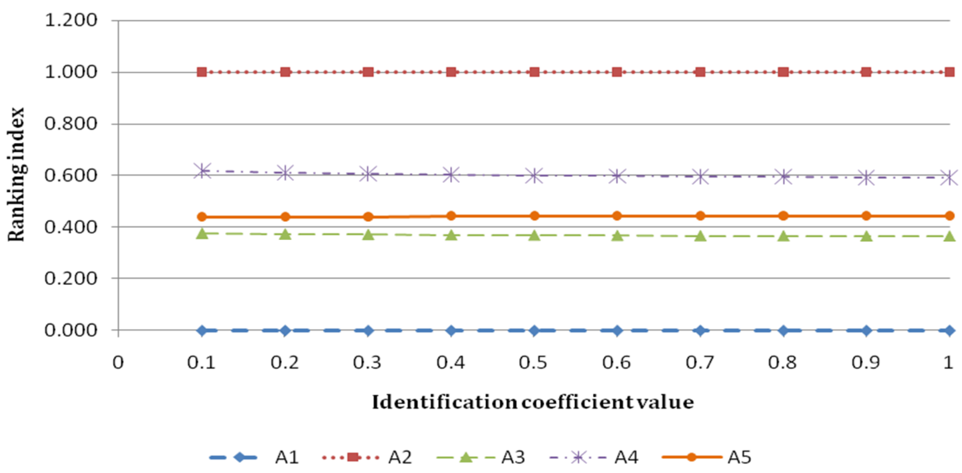

Figure 2. Variation analysis of Q_i for the sensitivity analysis.

New group decision model can take account of the gaps between the Q_i values of various alternatives appear larger when the coefficient cannot change remarkably, and they have enough stability.

5. Concluding Remarks and Future Research

The study introduced a new version of MCGDM model under uncertainty. Major concepts of IFSs theory and GRA were considered in the presented model along with the uncertain ELECTRE and VIKOR methods for selection and assessment problems. For this purpose, linguistic variables denoted by IF-numbers, by regarding the truth-membership and non-truth-membership functions, were utilized to report the importance of each candidate for the complicated problems. Then, a weighting approach was represented for Entropy analysis and IFSs. In addition, a new version of classical ELECTRE method was presented as indicated by the ideas of IFSs and grey theory. Finally, a new ranking index was introduced based on the VIKOR method concept for the appraisement. Furthermore, a case study from the recent literature for construction contractor assessment was indicated to successfully illustrate and validate the proposed model. Comparing with the previous studies, the proposed model assists the DMs or experts with a beneficial way to take fuzzy MCDM complex problems in more generalized methodology because of the way that it applied IFSs rather than conventional fuzzy sets to express the performance ratings of each candidate versus criteria. Although the new decision model provided is demonstrated by a decision problem of the contractor assessment, it is interesting to apply the model in other important management fields, like project selection.

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