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Image Mining Inranking Approach under Interval-Valued Hesitant Fuzzy Set Gr Selection

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ABSTRACT

In the last decades, considerations concerning the environmental problems cause skilled and educational efforts on inexperienced provider choice issues. during this sake, one among the most problems in evaluating the inexperienced provider choice issues, that might increase the uncertainty, is that the preferences of the experts' judgments concerning the candidate inexperienced suppliers. Therefore, getting ready AN professional system to guage the matter supported the historical information and therefore the experts' data are often smart. Image Mining provides AN professional analysis system to assess the candidate inexperienced suppliers underneath chosen criteria in an exceedingly multi-period approach. additionally, a ranking approach underneath interval-valued hesitant fuzzy set (IVHFS) setting is projected to pick the foremost acceptable inexperienced provider in designing horizon. within the projected ranking approach, the IVHFS and therefore the last aggregation approach is taken into account to margin the errors and to forestall information loss, severally. Hence, a comparative ANalysis is provided supported an illustrative example to point out the feasibleness of the projected approach.

Keywords : Green selection, Expert system, Ranking approach, Interval-valued hesitant fuzzy setting,Image Mining

I. INTRODUCTION

ASSESSMENT and selecting the acceptable inexperienced provider supported economical associated environmental criteria is an inevitable manner of a gaggle decision-making method. Thus, completely different info associated conflicting criteria is also revered to pick out the foremost appropriate candidate inexperienced provider in an inaccurate scenario. during this sake, inexperienced provider choice downside as a multi-criteria deciding downside can be the most issue for several corporations. during this respect, some researchers targeted on this fascinating topic supported cluster call analysis underneath precise/imprecise info.

Herein, Handfield et al. [1] used the AHP (Analytical Hierarchy Process) technique to judge the importance of varied environmental traits and specify the relative performance of the candidate suppliers underneath the traits. rule and Chinese [2] planned a multi-level gray entropy artificial analysis approach to avoid the lower weight issue that could lead on to additional powerful analysis technique. Hsu associated Hu [3] given a multi-criteria call model to see the dangerous substance management criteria and so used an ANP (Analytic Network Process) technique for solve the inexperienced provider choice downside. Feyzioğlu and Büyüközkan[4] ready a multi-criteria assessment approach supported Choquet integral operators for evaluating the performance of candidate inexperienced suppliers. Tsui and cyst [5] planned a hybrid multi-criteria cluster deciding (MCGDM) approach supported AHP, entropy, ELECTRE III (ELimination and selection Translating REality III) and also the linear assessment ways to help the producing corporations for choosing the most effective inexperienced provider.

In several real cases cluster decision-making issues underneath advanced conditions, increase the uncertainty within which specialists assign their preferences judgments supported inaccurate info. Hence, evaluating the candidate inexperienced suppliers underneath precise setting is tough and may be outlined underneath imprecisely/uncertainty setting.

consequently, the fuzzy pure mathematics associated its developments ar called an applicable tool to subsume uncertainty. Herein, some authors used this theory to address unsure things for evaluating the candidate inexperienced suppliers.

In this respect, Çifçi[6] extended a unique approach by mistreatment the fuzzy ANP technique supported incomplete preference relations underneath the multi-person deciding theme. Datta et al. [7] enforced a VIKOR technique underneath the interval-valued fuzzy setting setting to assess the most effective candidate inexperienced provider. Kannan et al. [8] given associate integrated TOPSIS(Technique for Order of Preference by Similarity to Ideal Solution) and AHP technique to see the importance of elect criteria in line with the preferences of the experts' judgments for finding the inexperienced provider choice downside. In their study, a multi-objective programming model is extended to assign the optimum order among them. Sepehriar et al. [9] given a replacement cluster deciding technique by mistreatment the quadrilateral fuzzy info for assessing the provider choice issues.
In addition, Khamseh associated Mahmoodi[10] planned an integrated TOPSIS-TODIM technique supported triangular fuzzy time perform to unravel the inexperienced provider choice issues. bird genus [11] developed associate outranking approach supported the preferences of the experts' judgments underneath the interval type-2 fuzzy set setting to see the most effective candidate provider. Cao et al. [12] given a replacement approach supported improvement model underneath intuitionistic fuzzy set setting to specify the subjective and objective weights, severally. Then, a TOPSIS technique is developed supported intuitionistic fuzzy set to rank the candidate inexperienced suppliers. Kannan et al. [13] planned a multi-criteria deciding technique supported axiomatic style and fuzzy pure mathematics to assess the candidate inexperienced suppliers. Celik et al. [14] similarly as [15, 16] targeted on ELECTRE ways by considering the interval type-2 fuzzy info to judge the candidate inexperienced supplying service suppliers.

Survey of provider choice similarly as inexperienced provider choice literature indicates that evaluating the issues ar provided supported the experts' opinions. during this respect, getting ready associate skilled system supported historical knowledge and experts' information to judge the inexperienced provider choice is additional fascinating as a result of reduction of the experts' opinions within the procedure of cluster deciding issues may decrease the uncertainty. to handle the problem, poor attention is provided to assess deciding issues supported skilled system [17-19].

However, this paper, careful associate skilled system to judge inexperienced provider choice issues known as skilled analysis system. additionally, a unique ranking approach is manipulated supported cluster call analysis and also the IVHFS theory to pick out the foremost appropriate inexperienced provider. IVHFS may facilitate the specialists by assignment some interval-values membership degrees for a candidate inexperienced provider on the conflicted criteria underneath a group to margin the errors. Moreover, the last aggregation approach is taken into account within the procedure of the planned ranking technique to avoid the loss of information.For the sake of clarity, the basic concepts and operators about the dynamic interval-valued hesitant fuzzy sets are presented in section 2. In section 3, an expert system is provided to evaluate the green supplier selection; then, a novel ranking approach is proposed to select the most suitable green supplier. In addition, computational experiment is provided in section 4, to show the feasibility of the presented approach. Finally, conclusions and future directions are prepared in section 5.

II. METHODS AND MATERIAL

PRELIMINARIES

In this section, the basic concept and operations on dynamic interval-valued hesitant fuzzy sets are defined. Furthermore, some operations, which are required for the proposed approach, are developed.

Definition 1 [20]. Let t as a time variable, then $\tilde{h}(t) = \cup_{\tilde{\gamma}(t)\in\tilde{h}(t)} \{[\tilde{\gamma}^L(t), \tilde{\gamma}^U(t)]\}$ is an interval-valued hesitant fuzzy variable (IVHFV), where $0 \le \tilde{\gamma}^L(t) \le \tilde{\gamma}^U(t) \le 1$. If $t = t_1, t_2, ..., t_p$, is defined for an IVHFV then $\tilde{h}(t_p) = \{\tilde{h}(t_1), \tilde{h}(t_2), ..., \tilde{h}(t_P)\}$ $\forall p = 1, 2, ..., P$ expressed as p IVHFEs which collected at p different periods.
Definition 2 [20]. Let $\tilde{h}(t_1)$ and $\tilde{h}(t_2)$ as two IVHFVs, then the following relations are defined:

$$\lambda\tilde{h}(t_1)=\cup_{\tilde{\gamma}(t_1)\in\tilde{h}(t_1)}\left\{\left[1-\left(1-\tilde{\gamma}^L(t_1)\right)^{\lambda},1-\left(1-\tilde{\gamma}^U(t_1)\right)^{\lambda}\right]\right\} \quad (1)$$

$$\left(\tilde{h}(t_1)\right)^{\lambda}=\cup_{\tilde{\gamma}(t_1)\in\tilde{h}(t_1)}\left\{\left[\left(\tilde{\gamma}^L(t_1)\right)^{\lambda},\left(\tilde{\gamma}^U(t_1)\right)^{\lambda}\right]\right\} \quad (2)$$

$$\tilde{h}(t_1)\oplus\tilde{h}(t_2)=\cup_{\tilde{\gamma}(t_1)\in\tilde{h}(t_1),\tilde{\gamma}(t_2)\in\tilde{h}(t_2)} \left\{\left[\tilde{\gamma}^L(t_1)+\tilde{\gamma}^L(t_2)-\tilde{\gamma}^L(t_1)\tilde{\gamma}^L(t_2),\tilde{\gamma}^U(t_1)+\tilde{\gamma}^U(t_2)-\tilde{\gamma}^U(t_1)\tilde{\gamma}^U(t_2)\right]\right\} \quad (3)$$

$$\tilde{h}(t_1)\otimes\tilde{h}(t_2)=\cup_{\tilde{\gamma}(t_1)\in\tilde{h}(t_1),\tilde{\gamma}(t_2)\in\tilde{h}(t_2)} \left\{\left[\tilde{\gamma}^L(t_1)\tilde{\gamma}^L(t_2),\tilde{\gamma}^U(t_1)\tilde{\gamma}^U(t_2)\right]\right\} \quad (4)$$

Definition 3. Let $E=\{\tilde{h}(t_1),\tilde{h}(t_2),\dots,\tilde{h}(t_p)\}$ be a collection of IVHFVs. Then the following extended relations are obtained based on definition 2:

$$\overset{P}{\underset{p=1}{\oplus}}\tilde{h}(t_p)=\cup_{\tilde{\gamma}(t_1)\in\tilde{h}(t_1),\tilde{\gamma}(t_2)\in\tilde{h}(t_2),\dots,\tilde{\gamma}(t_p)\in\tilde{h}(t_p)} \left\{\left[1-\prod_{p=1}^{P}(1-\tilde{\gamma}^L(t_p)),1-\prod_{p=1}^{P}(1-\tilde{\gamma}^U(t_p))\right]\right\} \quad (5)$$

$$\tilde{h}(t_1)\otimes\tilde{h}(t_2)\otimes\dots\otimes\tilde{h}(t_p)=\cup_{\tilde{\gamma}(t_1)\in\tilde{h}(t_1),\tilde{\gamma}(t_2)\in\tilde{h}(t_2),\dots,\tilde{\gamma}(t_p)\in\tilde{h}(t_p)} \left\{\left[\prod_{p=1}^{P}\tilde{\gamma}^L(t_p),\prod_{i=1}^{P}\tilde{\gamma}^U(t_p)\right]\right\} \quad (6)$$

Definition 4 [20]. A dynamic interval-valued hesitant fuzzy weighted geometric (DIVHFWG) relation is defined as follows:

$$DIVHFWG_{w(t)}\left(\tilde{h}(t_1),\tilde{h}(t_2),\dots,\tilde{h}(t_p)\right)=\overset{P}{\underset{p=1}{\oplus}}\tilde{h}(t_p)^{w(t_p)} =\cup_{\tilde{\gamma}(t_p)\in\tilde{h}(t_p),p=1,2,\dots,P}\left\{\left[\prod_{p=1}^{P}(\tilde{\gamma}^L(t_p))^{w(t_p)},\prod_{p=1}^{P}(\tilde{\gamma}^U(t_p))^{w(t_p)}\right]\right\} \quad (7)$$

where $w(t)=(w(t_1),w(t_2),\dots,w(t_p))^T$ are the weight vector of the time series $t=t_1,t_2,\dots,t_p$ and $w(t)>0,\sum_{p=1}^{P}w(t_p)=1$.

Definition 5. The dynamic interval-valued hesitant fuzzy geometric (DIVHFG) operator could be defined based on definition 4, as follows:

$$DIVHFG\left(\tilde{h}(t_1),\tilde{h}(t_2),\dots,\tilde{h}(t_p)\right)=\overset{P}{\underset{p=1}{\oplus}}\tilde{h}(t_p)^{\frac{1}{P}} =\cup_{\tilde{\gamma}(t_p)\in\tilde{h}(t_p),p=1,2,\dots,P}\left\{\left[\prod_{p=1}^{P}(\tilde{\gamma}^L(t_p))^{\frac{1}{P}},\prod_{p=1}^{P}(\tilde{\gamma}^U(t_p))^{\frac{1}{P}}\right]\right\} \quad (8)$$

Definition 6. The dynamic interval-valued hesitant fuzzy Euclidean (DIVHFE) distance measure and the dynamic interval-valued hesitant fuzzy hamming (DIVHFH) distance measure are defined, respectively as follows:

$$d\left(\tilde{h}(t_1),\tilde{h}(t_2)\right)_{DIVHFE}=\sqrt{\frac{1}{2l_{x_i}}\sum_{\lambda=1}^{l_{x_i}}\left(\left|\tilde{h}^{\sigma(\lambda)L}(t_1)-\tilde{h}^{\sigma(\lambda)L}(t_2)\right|^2+\left|\tilde{h}^{\sigma(\lambda)U}(t_1)-\tilde{h}^{\sigma(\lambda)U}(t_2)\right|^2\right)} \quad (9)$$

$$d\left(\tilde{h}(t_1),\tilde{h}(t_2)\right)_{DIVHFH}=\frac{1}{2l_{x_i}}\sum_{\lambda=1}^{l_{x_i}}\left(\left|\tilde{h}^{\sigma(\lambda)L}(t_1)-\tilde{h}^{\sigma(\lambda)L}(t_2)\right|+\left|\tilde{h}^{\sigma(\lambda)U}(t_1)-\tilde{h}^{\sigma(\lambda)U}(t_2)\right|\right) \quad (10)$$

where $\tilde{h}(t_1)$ and $\tilde{h}(t_2)$ are IVHFVs which indicates as $\tilde{h}^{\sigma(\lambda)}(t_1)=\left[\tilde{h}^{\sigma(\lambda)L}(t_1),\tilde{h}^{\sigma(\lambda)U}(t_1)\right]$, $\tilde{h}^{\sigma(\lambda)}(t_2)=\left[\tilde{h}^{\sigma(\lambda)L}(t_2),\tilde{h}^{\sigma(\lambda)U}(t_2)\right]$ respectively; and $\tilde{h}^{\sigma(\lambda)}(t_1)$, $\tilde{h}^{\sigma(\lambda)}(t_2)$ are the λth largest intervals in $\tilde{h}(t_1)$ and $\tilde{h}(t_2)$, respectively.

Definition 7. The dynamic interval-valued hesitant fuzzy decision matrix $\left(\tilde{D}=\left(\tilde{h}_{ij}(t_p)\right)_{m\times n}\right)$ could be normalized $\left(\tilde{N}=\left(\tilde{f}_{ij}(t_p)\right)_{m\times n}\right)$ based on the following relations.

$$\tilde{f}_{ij}(t_p)=\begin{cases}\left\{\left[\tilde{\gamma}_{ij}^L(t_p),\tilde{\gamma}_{ij}^U(t_p)\right]\right\} & \text{For positive criteria}\\ \left\{\left[1-\tilde{\gamma}_{ij}^L(t_p),1-\tilde{\gamma}_{ij}^U(t_p)\right]\right\} & \text{For negative criteria}\end{cases} \quad (11)$$

$$\forall i=1,2,\dots,m;\ j=1,2,\dots,n,\ p=1,2,\dots,P$$

III. RESULTS AND DISCUSSION

1. Proposed Approach

In this section, associate analysis module is bestowed supported the skilled system; next, obtained results from the projected skilled analysis system that is dynamic interval-valued hesitant fuzzy call matrix is taken into account because the input file of the ranking module. during this sake, the relative importance of every criterion is set supported preferences experts' opinions. Then the candidates ar graded supported a replacement ranking methodology beneath uncertainty. Hereupon, Fig. one diagrammatical the structure of the projected approach.

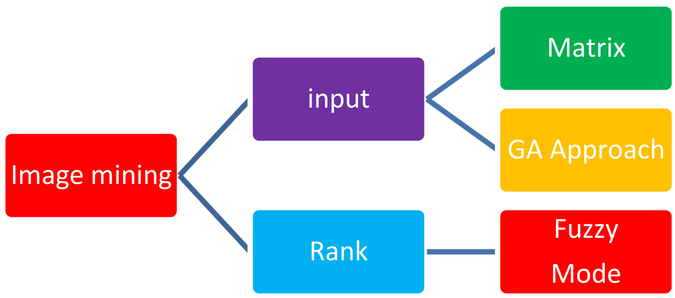

Figure 1. Hierarchical structure of the proposed approach

A. Proposed Evaluation Approach

In this section, an expert system approach is proposed to evaluate the green supplier selection problem. To address the issue, a group of experts $(E_k, k=1,2,\dots,K)$ is established to judge the candidate green suppliers

$(S_i, i=1,2,....,m)$ under conflicted criteria $(C_i, j=1,2,....,n)$ in each period $(t_p, p=1,2,....,P)$. Accordingly, the evaluation of the candidate green suppliers is determined based on the historical data and the preferences experts' judgments under the proposed expert evaluation system. Thus, the interval-valued hesitant fuzzy group decision matrix is obtained from the proposed expert evaluation module for each period based on linguistic terms, which are converted to interval-valued hesitant fuzzy elements (IVHFEs). In this sake, the linguistic terms for assessment the criteria weights and the rating of candidates are converted to IVHFEs based on Table I and II, respectively.

TABLE I
LINGUISTIC VARIABLES FOR RATING THE IMPORTANCE OF CRITERIA

Linguistic variables	Interval-valued hesitant fuzzy elements
Very important (VI)	[0.90,0.90]
Important (I)	[0.75, 0.80]
Medium (M)	[0.50, 0.55]
Unimportant (UI)	[0.35, 0.40]
Very unimportant (VUI)	[0.10,0.10]

TABLE II
LINGUISTIC VARIABLES FOR RATING THE POTENTIAL CANDIDATES

Linguistic variables	Interval-valued hesitant fuzzy elements
Extremely good (EG)	[1.00,1.00]
Very very good (VVG)	[0.90,0.90]
Very good (VG)	[0.80, 0.90]
Good (G)	[0.70, 0.80]
Medium good (MG)	[0.60, 0.70]
Fair (F)	[0.50, 0.60]
Medium bad (MB)	[0.40, 0.50]
Bad (B)	[0.25, 0.40]
Very bad (VB)	[0.10, 0.25]
Very very bad (VVB)	[0.10,0.10]

Hence, an evaluation module based on expert evaluation system is proposed to design the production system for the green supplier selection problem. To elucidate on, an expert system based on rule-based approach and regarding to the aforementioned statements is elaborated. In this respect, a meta-rule is defined to determine the framework of the evaluation module, and then some rule-sets based on the involved parameters are established to satisfy the conflicted criterions in meta-rule for assessment of the candidate green suppliers. In other words, when the value of a positive criterion among the involved parameters is low; then, the candidate green supplier is bad vs. when the value of a negative criterion among the involved parameters is high; then the candidate green supplier is bad, too. Hence, the manipulated rule-based approach is coded by MATLAB R2013a software and all results are obtained on a 3 GHz computer with 4 GB RAM. However, the candidates are evaluated based on the following conflicted criteria:

- Cost (C_1);
- Quality (C_2);
- Capability of supplier (C_3);
- Environmental competency (C_4).

In this respect, the manipulated rule-based approach is expressed to evaluate the candidate green suppliers in brief module as follows:

Candidate inexperienced provider analysis rules set

Rule C;

1. Candidate inexperienced provider is dangerous in price criterion
2. If the buying worth of the candidate inexperienced provider is high
3. And therefore the product price of the candidate inexperienced provider is high
4. And therefore the price of part disposal of the candidate inexperienced provider is high
5. And therefore the provision price of the candidate inexperienced provider is high
6. THEN the candidate inexperienced provider in price criterion is dangerous

Rule Q;

1. Candidate inexperienced provider is dangerous in quality criterion
2. If rejection quantitative relation of the candidate inexperienced provider is high
3. and therefore the quality assurance of the candidate inexperienced provider is low

4. and therefore the method capability of the candidate inexperienced provider is low
5. THEN the candidate inexperienced provider in quality criterion is dangerous

Rule CS;

1. Candidate inexperienced provider is dangerous in capability of provider criterion
2. If interval of the candidate inexperienced provider is high
3. And therefore the technology level of the candidate inexperienced provider is low
4. And therefore the provision capability of the candidate inexperienced provider is low
5. And therefore the capability of development of the candidate inexperienced provider is low
6. THEN the candidate inexperienced provider in capability of provider criterion is dangerous

Rule EC;

1. Candidate inexperienced provider is dangerous in environmental competence criterion
2. If atmosphere protection system certification of the candidate inexperienced provider is low
3. and therefore the air emissions of the candidate inexperienced provider is high
4. And therefore the waste water of the candidate inexperienced provider is high
5. And therefore the pollution reduction capability of the candidate inexperienced provider is low
6. And therefore the recycle capability of the candidate inexperienced provider is low
7. THEN the candidate inexperienced provider in environmental competence criterion is dangerous

Therefore, the dynamic interval-valued hesitant fuzzy cluster call matrix is obtained supported the same rules set relating to to linguistic variables. Then, the linguistic variables area unit born-again to IVHFEs per Tables I and II.

B. Proposed Ranking Approach

In this section, a novel ranking approach is elaborated under dynamic interval-valued hesitant fuzzy set environment to choose the most suitable candidate green supplier. IVHFS could help the experts by assigning some interval-values membership degrees for a candidate green supplier versus the conflicted criteria under a set to margin the errors. In addition, the last aggregation approach is considered in the process of the proposed ranking method to prevent the loss of data. Therefore, the novel proposed ranking approach is provided under following steps:

Step 1. The dynamic interval-valued hesitant fuzzy group decision matrix (DIVHF-GDM) is obtained from the proposed evaluation module, which represented as follows:

$$G^p = \begin{array}{c} \\ A_1 \\ \vdots \\ A_m \end{array} \begin{array}{c} C_1 \quad\quad\quad \cdots \quad\quad\quad C_n \\ \left[\begin{array}{ccc} \left\{\left[\mu_{11}^{L1p},\mu_{11}^{U1p}\right],\left[\mu_{11}^{L2p},\mu_{11}^{U2p}\right],\ldots,\left[\mu_{11}^{Lkp},\mu_{11}^{Ukp}\right]\right\} & \cdots & \left\{\left[\mu_{1n}^{L1p},\mu_{1n}^{U1p}\right],\left[\mu_{1n}^{L2p},\mu_{1n}^{U2p}\right],\ldots,\left[\mu_{1n}^{Lkp},\mu_{1n}^{Ukp}\right]\right\} \\ \vdots & \ddots & \vdots \\ \left\{\left[\mu_{m1}^{L1p},\mu_{m1}^{U1p}\right],\left[\mu_{m1}^{L2p},\mu_{m1}^{U2p}\right],\ldots,\left[\mu_{m1}^{Lkp},\mu_{m1}^{Ukp}\right]\right\} & \cdots & \left\{\left[\mu_{mn}^{L1p},\mu_{mn}^{U1p}\right],\left[\mu_{mn}^{L2p},\mu_{mn}^{U2p}\right],\ldots,\left[\mu_{mn}^{Lkp},\mu_{mn}^{Ukp}\right]\right\} \end{array}\right]_{m\times n} \end{array} \quad \forall p = 1,2,\ldots,P \tag{12}$$

where G^p is the DIVHF-GDM in period p and $\left[\mu_{mn}^{Lk},\mu_{mn}^{Uk}\right]$ represented the opinion of kth expert for mth candidate green supplier under the nth criterion based on the IVHFS.

Step 2. Normalize the DIVHF-GDM regarding to the definition 7.

Step 3. The criteria weights are expressed based on the preferences of the experts' judgments for each period. The final weight of each criterion in planning horizon is computed as follows:

$$\varpi_j^{Np} = DIVHFG\left(\varpi_{1j}^p,\varpi_{2j}^p,\ldots,\varpi_{Kj}^p\right) = \mathop{\oplus}_{k=1}^{K}\left(\varpi_{kj}^p\right)^{\frac{1}{K}} = \bigcup_{\left[\varpi_{kj}^{Lp},\varpi_{kj}^{Up}\right]\in\varpi_{kj}^p,k=1,2,\ldots,K} \left\{ \frac{\prod_{k=1}^{K}(\varpi_{kj}^{Lp})^{\frac{1}{K}} + \prod_{k=1}^{K}(\varpi_{kj}^{Up})^{\frac{1}{K}}}{\sum_{j=1}^{n}\left(\prod_{k=1}^{K}(\varpi_{kj}^{Lp})^{\frac{1}{K}} + \prod_{k=1}^{K}(\varpi_{kj}^{Up})^{\frac{1}{K}}\right)} \right\} \quad \forall j,p \tag{13}$$

where ϖ_{kj}^p is the relative importance of jth criterion which determined by kth expert in period p, and ϖ_j^{Np} is the normalized weight of jth criterion in period p.

Step 5. Construct the weighted normalized DIVHF-GDM $\left(T_{k(ij)}^p = \left[T_{k(ij)}^{Lp},T_{k(ij)}^{Up}\right]_{m\times n}\right)$ for each expert based on the criteria weights in each period.

$$T_k^p = \begin{array}{c} \\ A_1 \\ \vdots \\ A_m \end{array} \begin{array}{c} C_1 \quad\quad \cdots \quad\quad C_n \\ \left(\begin{array}{ccc} \varpi_1^{Np}\left[\mu_{11}^{Lkp},\mu_{11}^{Ukp}\right] & \cdots & \varpi_n^{Np}\left[\mu_{1n}^{Lkp},\mu_{1n}^{Ukp}\right] \\ \vdots & \ddots & \vdots \\ \varpi_1^{Np}\left[\mu_{m1}^{Lkp},\mu_{m1}^{Ukp}\right] & \cdots & \varpi_n^{Np}\left[\mu_{mn}^{Lkp},\mu_{mn}^{Ukp}\right] \end{array}\right)_{m\times n} \end{array} \quad \forall k,p \tag{14}$$

Step 6. Define dynamic interval-valued hesitant fuzzy positive ideal solution (DIVHF-PIS) and the dynamic interval-valued hesitant fuzzy negative ideal solution (DIVHF-NIS) as below:

$$A_{jk}^{*p}=\left\{h_{1k}^{*p},h_{2k}^{*p},...,h_{nk}^{*p}\right\} \quad (15)$$

$$h_{jk}^{*p}=\begin{cases}\left\{x_j,\max_i\left\langle T_{k(ij)}^{p}\right\rangle\right\}, & \forall J,k,p\\ \left\{x_j,\min_i\left\langle T_{k(ij)}^{p}\right\rangle\right\}, & \forall J',k,p\end{cases} \quad (16)$$

$$A_{jk}^{-p}=\left\{h_{1k}^{-p},h_{2k}^{-p},...,h_{nk}^{-p}\right\} \quad (17)$$

$$h_{jk}^{-p}=\begin{cases}\left\{x_j,\min_i\left\langle T_{k(ij)}^{p}\right\rangle\right\}, & \forall J,k,p\\ \left\{x_j,\max_i\left\langle T_{k(ij)}^{p}\right\rangle\right\}, & \forall J',k,p\end{cases} \quad (18)$$

where J is a set of benefit criteria and J' is a set of cost criteria.

Step 7. Determine the distance values between the weighted normalized DIVHF-GDM (T_k^p) and DIVHF-PIS ($\Im_i^{*kp}$), and DIVHF-NIS ($\Im_i^{-kp}$) as follows:

$$\Im_i^{*kp}=\sum_{j=1}^{n}\sqrt{\frac{1}{2l_{x_i}}\sum_{\lambda=1}^{l_{x_i}}\left(\left|T_{k(ij)}^{Lp}-A_{jk}^{*Lp\sigma(\lambda)}\right|^2+\left|T_{k(ij)}^{Up}-A_{jk}^{*Up\sigma(\lambda)}\right|^2\right)} \quad \forall i,k,p \quad (19)$$

$$\Im_i^{-kp}=\sum_{j=1}^{n}\sqrt{\frac{1}{2l_{x_i}}\sum_{\lambda=1}^{l_{x_i}}\left(\left|T_{k(ij)}^{Lp}-A_{jk}^{-Lp\sigma(\lambda)}\right|^2+\left|T_{k(ij)}^{Up}-A_{jk}^{-Up\sigma(\lambda)}\right|^2\right)} \quad \forall i,k,p \quad (20)$$

Step 8. Specify the closeness coefficient to determine the relative importance of each candidate green supplier in planning horizon ($\wp_i$).

$$\wp_i=\frac{\prod_{p=1}^{P}\prod_{k=1}^{K}\left(\Im_i^{-kp}\right)^{\frac{1}{KP}}}{\prod_{p=1}^{P}\prod_{k=1}^{K}\left(\Im_i^{*kp}\right)^{\frac{1}{KP}}+\prod_{p=1}^{P}\prod_{k=1}^{K}\left(\Im_i^{-kp}\right)^{\frac{1}{KP}}} \quad \forall i \quad (21)$$

Step 9. Rank the candidate green suppliers by decreasing sorting of closeness coefficient in planning horizon.

2. Illustrative Example

In this section, an illustrative example is provided to show the capability of the proposed approach. In addition, a comparative analysis is determined to indicate the feasibility of the proposed evaluation and the ranking module. In this regard, three candidate green suppliers (S_1, S_2, S_3) are evaluated based on the opinions of three experts (E_1, E_2, E_3) under four criteria (C_1, C_2, C_3, C_4) in two periods (t_1, t_2). The dynamic interval-valued hesitant fuzzy group decision matrix and the relative significance of each criterion are obtained based on the elaborated expert evaluation system and represented in Tables III and IV, respectively.

TABLE III
THE OBTAINED GREEN SUPPLIER EVALUATION FROM EXPERT EVALUATION SYSTEM

First period (t_1)				
Criteria	Candidates	Experts		
		E_1	E_2	E_3
C_1	S_1	[0.80, 0.90]	[0.80, 0.90]	[0.70, 0.80]
	S_2	[0.50, 0.60]	[0.60, 0.70]	[0.60, 0.70]
	S_3	[0.70, 0.80]	[0.80, 0.90]	[0.70, 0.80]
C_2	S_1	[0.60, 0.70]	[0.70, 0.80]	[0.70, 0.80]
	S_2	[0.70, 0.80]	[0.80, 0.90]	[0.80, 0.90]
	S_3	[0.60, 0.70]	[0.50, 0.60]	[0.50, 0.60]
C_3	S_1	[0.50, 0.60]	[0.50, 0.60]	[0.40, 0.50]
	S_2	[0.70, 0.80]	[0.60, 0.70]	[0.70, 0.80]
	S_3	[0.60, 0.70]	[0.60, 0.70]	[0.50, 0.60]
C_4	S_1	[0.80, 0.90]	[0.80, 0.90]	[0.70, 0.80]
	S_2	[0.70, 0.80]	[0.80, 0.90]	[0.90,0.90]
	S_3	[0.70, 0.80]	[0.70, 0.80]	[0.60, 0.70]
Second period (t_2)				
Criteria	Candidates	Experts		
		E_1	E_2	E_3
C_1	S_1	[0.80, 0.90]	[0.90,0.90]	[0.80, 0.90]
	S_2	[0.60, 0.70]	[0.70, 0.80]	[0.70, 0.80]
	S_3	[0.80, 0.90]	[0.80, 0.90]	[0.70, 0.80]
C_2	S_1	[0.70, 0.80]	[0.70, 0.80]	[0.80, 0.90]
	S_2	[0.90,0.90]	[0.80, 0.90]	[0.80, 0.90]
	S_3	[0.70, 0.80]	[0.80, 0.90]	[0.60, 0.70]
C_3	S_1	[0.50, 0.60]	[0.60, 0.70]	[0.50, 0.60]
	S_2	[0.70, 0.80]	[0.60, 0.70]	[0.80, 0.90]

	S_3	[0.70, 0.80]	[0.60, 0.70]	[0.60, 0.70]
C_4	S_1	[0.70, 0.80]	[0.70, 0.80]	[0.80, 0.90]
	S_2	[0.90,0.90]	[0.80, 0.90]	[0.80, 0.90]
	S_3	[0.80, 0.90]	[0.60, 0.70]	[0.60, 0.70]

TABLE IV
THE OBTAINED CRITERIA IMPORTANCE BASED ON EXPERT EVALUATION SYSTEM

Criteria	Periods	Experts		
		E_1	E_2	E_3
C_1	t_1	[0.75, 0.80]	[0.90,0.90]	[0.90,0.90]
	t_2	[0.50, 0.55]	[0.75, 0.80]	[0.90,0.90]
C_2	t_1	[0.75, 0.80]	[0.50, 0.55]	[0.50, 0.55]
	t_2	[0.50, 0.55]	[0.50, 0.55]	[0.75, 0.80]
C_3	t_1	[0.90,0.90]	[0.90,0.90]	[0.75, 0.80]
	t_2	[0.75, 0.80]	[0.75, 0.80]	[0.75, 0.80]
C_4	t_1	[0.50, 0.55]	[0.50, 0.55]	[0.75, 0.80]
	t_2	[0.75, 0.80]	[0.75, 0.80]	[0.50, 0.55]

Herein, the proposed ranking approach is considered to rank the candidate green suppliers. In this sake, the DIVHF-GDM is normalized based on definition 7 (step 2). In addition, the normalized weight of each criterion is determined based on (13) and represented in Table V. Then, the weighted normalized DIVHF-GDM is founded based on (14). Hence, the DIVHF-PIS and DIVHF-NIS are specified regarding to (15)-(18). In this respect, the distance values between the weighted normalized DIVHF-GDM and DIVHF-PIS, and DIVHF-NIS are computed by using (19) and (20). Give the results in Tables VI and VII, respectively.

TABLE V
THE CRITERIA WEIGHT REGARDING TO EXPERTS' OPINIONS

Criteria	Periods	Aggregated judgments for criteria weights	ϖ_j^{Np}
C_1	t_1	[0.84693, 0.86535]	0.29442
	t_2	[0.69623, 0.73434]	0.25835
C_2	t_1	[0.57235, 0.62316]	0.20557
	t_2	[0.57235, 0.62316]	0.21590
C_3	t_1	[0.84693, 0.86535]	0.29442
	t_2	[0.75000, 0.80000]	0.27991
C_4	t_1	[0.57235, 0.62316]	0.20557
	t_2	[0.65518, 0.70607]	0.24583

TABLE VI
THE DISTANCE VALUES BETWEEN THE WEIGHTED NORMALIZED DIVHF-GDM AND DIVHF-PIS

t_1	Experts		
	E_1	E_2	E_3
S_1	0.07944	0.05000	0.14138
S_2	0.07944	0.04655	0.02944
S_3	0.07055	0.10304	0.20241
t_2	Experts		
	E_1	E_2	E_3
S_1	0.12899	0.04617	0.08397
S_2	0.05167	0.04084	0.02583
S_3	0.05152	0.06743	0.17416

TABLE VII
THE DISTANCE VALUES BETWEEN THE WEIGHTED NORMALIZED DIVHF-GDM AND DIVHF-NIS

t_1	Experts		
	E_1	E_2	E_3
S_1	0.07944	0.10822	0.09111
S_2	0.07944	0.11167	0.20241
S_3	0.08833	0.05889	0.02944
t_2	Experts		
	E_1	E_2	E_3
S_1	0.05167	0.06543	0.11818
S_2	0.12899	0.07076	0.17632
S_3	0.13224	0.04743	0.02799

Finally, the relative importance of each candidate green supplier in the planning horizon is determined based on proposed closeness coefficient index ((21)). In this sake, the candidate green suppliers are ranked by decreasing sorting of their closeness coefficient value. In addition, the Peng and Wang [20]' method is implemented to our illustrative example for comparing the obtained ranking results to indicate the verifying of the proposed approach. The results show that, both methods achieved the same ranking results and selected the second green supplier as the most suitable candidate. Give the aforementioned results in Table VIII.

TABLE VIII
THE CLOSENESS COEFFICIENT OF EACH CANDIDATE AND COMPARATIVE ANALYSIS

Candidate green suppliers	$\wp_i$	Ranked by proposed approach	Ranked by Peng and Wang [20]' method
S_1	0.50451	2	2
S_2	0.73716	1	1
S_3	0.35815	3	3

As indicated in Tables VIII, both methods selected the second green supplier as the best candidate and specified the third green supplier as the worst candidate. In this respect, both ranking methods are tailored based on dynamic interval-valued hesitant fuzzy set, but the proposed approach of this study considered the weight of each criterion in the procedure of the proposed raking method to decrease the errors. In this respect, a group of experts is founded to evaluate the importance of the criteria and assessment the candidate green suppliers versus the conflicted criteria. In addition, the last aggregation approach is considered in the procedure of the proposed ranking approach to lead a precise solution by preventing the loss of data.

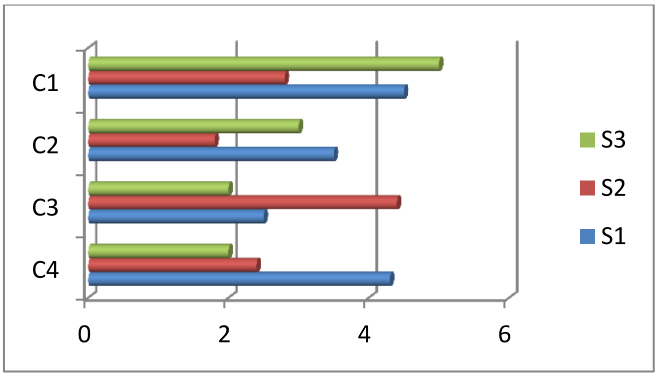

Figure 2. Overall Result Analysis

IV.CONCLUSION

Green provider choice issues square measure the most issue for firms to reinforce their economical and environmental performances. to deal with this issue, selecting the simplest inexperienced provider as a gaggle decision-making drawback may play a vital role for these firms. during this sake, this paper bestowed AN skilled system to judge the inexperienced provider choice drawback named skilled analysis system to decrease the uncertainty of skilleds' judgments by considering the information of expert and historical knowledge, at the same time. Then, a replacement interval-valued hesitant fuzzy ranking technique is ready underneath dynamic atmosphere to point the simplest and worst inexperienced provider. The projected ranking approach is elaborate supported last aggregation approach to avoid the loss of information. during this respect, the preferences of the experts' judgments square measure aggregative within the last step, that may lead to interference of the info loss. Finally, AN illustrative example is provided to point out the relevancy of the projected modules. during this sake, the obtained ranking leads to compared with a projected technique within the recent literature show that constant ranking results that is diagrammatic the practicability of the projected approach. For future direction, the hierarchical data structure for outlining the standards is additional attention-grabbing to judge the inexperienced provider choice issues fittingly. additionally, decisive the weights of every skilled and every criterion supported novel approaches may enhance the projected ranking technique. Consequently, considering the specialists and criteria weights within the procedure of the projected ranking approach may lead to express answer.

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