

Supplier Evaluation in Construction Projects Using a Modified MADM Model Based on Complex Spherical Fuzzy Soft Sets

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ABSTRACT

Supply chain management plays a crucial role in the construction of any building. Since every construction project entirely depends on the supplier, selecting a suitable supplier is of utmost importance. However, this selection process may involve uncertainty and ambiguity due to incomplete or imprecise information regarding the supplier and the construction project. To overcome such challenges, this article presents a modified multi-attribute decision-making (MADM) model based on the complex spherical fuzzy soft set. After presenting the MADM model, the article provides a case study related to supply chain management, which is then solved using the proposed modified model. This approach provides a ranking of alternatives, from the best supplier to the worst, to support well-informed decision-making. Furthermore, a sensitivity analysis of the proposed model is conducted, demonstrating its robustness and efficiency. Finally, the article concludes with a comprehensive synthesis of the research and a discussion of future directions.

Keywords: Spherical fuzzy Set, Soft Set, Complex Spherical fuzzy Soft Set, Distance function, Decision making, Supply chain management.

1. Introduction

Supply chain management comprises of comprehensive oversight of how goods, data and funds move between the original supplier and the final customer. This complex network helps the sourcing, procurement, conversion, and logistics processes to ensure the delivery of goods and services is efficient. The main objectives are to maximize value creation within the entire chain of supply, cut expenses and enhance customer satisfaction. In the current competitive business environments, businesses need to have a good supply chain management in order to stay competitive. In the simplest of its forms, it unites businesses that are geographically separated in order to align business procedures between the source

Online ISSN

3007-3197

Print ISSN

3007-3189

<http://amresearchreview.com/index.php/Journal/about>

suppliers and the end consumers. [1] This complex system has numerous processes including the purchase of raw materials, production, distribution, or even disposal of garbage thus the need to have such great management in order to be efficient and communicate effectively with all the stakeholders. decision-making is a key to maintaining the balance between conflicting goals, including lowering costs and increasing the quality and speed of provided services. To overcome these issues and reduce risks to gain a competitive advantage, businesses may become more responsive and efficient with a firm foundation on which to base their decision-making.

Multi-attribute decision-making models play a significant role in such a complex environment. When one has to decide on something with more than one, and in most cases, incompatible factors to consider, then these models give the structured method of examining and choosing the most suitable alternative. There will be several objectives that will be needed to arrive at the best option since to the complexity of modern supply chains which can be described as massive complex networks whereby there are multiple constantly moving components and information transactions. As an example, when choosing a supplier, it is not only about finding the most appropriate price but also evaluating such aspects as the quality of the product, its capacity, the reliability of its delivery, its ethical conduct, and its influence on the environment. The same factors are considered in the process of deciding where to open a new distribution center, including the supply of labor, the price of land, ease of accessing the market, transport facilities and regulatory policies. Under such cases, [2] MADM models can be implemented by decision-makers to quantify subjective assessments, model such various attributes, and compare possible alternatives in a systematic manner to reach a more credible and persuasive decision. [3]

The fuzzy set theory is a handy tool in solving the inherent imprecision and qualitative nature

of decision-making in ambiguity and uncertainty which is often involved in complex domains, such as supply chain management. Fuzzy sets introduce the element of partial membership, instead of the strict binary membership (an element is a complete member of a set or none whatsoever). Consequently, the extent to which an element can be a member of a set can be represented by a membership

Online ISSN

3007-3197

Print ISSN

3007-3189

<http://amresearchreview.com/index.php/Journal/about>

function which ranges between 0 (no membership) and 1 (complete membership). The measure of the levels of belonging is such that an analytical and operational imprecise information through mathematic analysis is examined and handled in fuzzy sets. This will ease the integration to the systems of analytical processes of the qualitative factors and individualized human choices. This ability can be useful in eliminating confidence that most life situations hold in decision making when complete information is not available or hard definitions are not given so as to allow more tangible and natural judgments.

2. Basic definitions

Fuzzy Set [4]: If $\tilde{F}$ defines mapping and G represents the fundamental collection of items defined as $\{Q, G_1(Q)|Q \in G\}$ such that $G_+ : Q \rightarrow G^{[0,1]}$ where $G_+(Q)$ denotes the belonging value of G in $\tilde{B}$ and $G^{[0,1]}$ and $G^{[0,1]}$ denote unit closed interval.

Intuitionistic Fuzzy Set [5]: If $\tilde{F}$ defines mapping and G represents the fundamental collection of items defined as $\{Q, G_+(Q), G_-(Q)|Q \in G\}$ such that $G_+, G_- : Q \rightarrow G^{[0,1]}$ where $G_+(Q), G_-(Q)$ denotes the belonging value and not belonging value of G respectively in $\tilde{B}$ and $G_+(Q) + G_-(Q) \in [0, 1]$ and $G^{[0,1]}$ denote unit closed interval.

Complex Fuzzy Set [6]: If $\tilde{F}$ is complex fuzzy set over the fundamental collection of

items G defined as $\{Q, G_1(Q)|Q \in G\}$ such that $G_+ = E_+(Q)\exp^{il_+(Q)}$ where $E_+(Q) \in [0, 1]$ and

$il_+(Q) \in [0, 2\pi]$

Complex intuitionistic Fuzzy Set [7]: If $\tilde{F}$ represent complex intuitionistic fuzzy set and G represents the fundamental collection of items defined as $\{Q, G_+(Q), G_-(Q)|Q \in G\}$ such that $G_+ = E_+(Q)\exp^{il_+(Q)}$, $G_- = E_-(Q)\exp^{il_-(Q)}$ where $G_+(Q), G_-(Q) \in [0, 1]$ and $l_+(Q), l_-(Q) \in [0, 2\pi]$.

Complex Spherical Fuzzy Set [8]: If $\tilde{F}$ defines and G the fundamental collection

of items defined as $\{Q, G_+(Q), G_-(Q), G_\phi(Q)|Q \in G\}$ such that $G_+ = E_+(Q)\exp^{il_+(Q)}$, $G_- = E_-(Q)\exp^{il_-(Q)}$ and $G_\phi = E_\phi(Q)\exp^{il_\phi(Q)}$ where $(E_+(Q))^2 + (E_-(Q))^2 + (E_\phi(Q))^2 \in [0, 1]$ and $(l_+(Q))^2 + (l_-(Q))^2 + (l_\phi(Q))^2 \in [0, 2\pi]$

Fuzzy Soft Set [10]: Let B be the collection of attributes and S be the collection of fundamental set. Then $(FSS, \tilde{p})$ referred as an fuzzy soft set

over S

$$(S, \check{K}) = \{(\check{p}, \check{K}(\check{p})) \mid \check{p} \in S, \check{K}(\check{p}) \subseteq F(S)\}$$

where $\check{p} : S \rightarrow F(S)$ $F(S)$ is collection of all fuzzy subset of S.

Intuitionistic Fuzzy Soft Set [11] Let subset B be the collection of attributes of the universal set S. Then the intuitionistic fuzzy soft set is defined as

$$(S, \check{K}) = \{(\check{p}, \check{K}(\check{p})) \mid \check{p} \in S, \check{K}(\check{p}) \in I(S)\}$$

where $\check{p} : S \rightarrow I(S)$ $I(S)$ is collection of all intuitionistic fuzzy subset of S.

Complex Spherical Fuzzy Soft Set [25] Let subset B be the collection of attributes of the universal set S. Then the complex spherical fuzzy soft set is defined as

$$(S, \check{K}) = \{(\check{p}, \check{K}(\check{p})) \mid \check{p} \in S, \check{K}(\check{p}) \in Sp(S)\}$$

where $\check{p} : S \rightarrow Sp(S)$, and $Sp(S)$ is collection of all fuzzy subset of S.

Methodology

This section provided the modified multi-attribute decision making model based on complex spherical fuzzy set, which is presented by Asghar et al. [25]. In order to explain the problem of supplier selection based on CSFSS, this section first proposes an algorithm based on MADM. In SCM companies and customers faces many problems to get authentic, qualitative and cost effective product. The quality of the building material accessible is worry for companies, As if one company have to buy building material from two comities there are many things to check whether the building materials quality is good, cost effective and meet the requirements. The following phases make up the described MADM technique based on the complex spherical fuzzy soft set. In order to explain the problem of supplier selection based on CSpFSS, this section proposes another algorithm based on MADM.

Algorithm This algorithm consist of following steps:

1. Considering the essential sets and opinions of decision makers, construct CSpFSS $\tilde{\mathfrak{S}}$ i.e

$$\tilde{\mathfrak{S}} = \{(\check{\varrho}, \langle \mathfrak{I}_+(\check{\varrho}) \exp^{il_+(\check{\varrho})}, \mathfrak{I}_-(\check{\varrho}) \exp^{il_-(\check{\varrho})}, \mathfrak{I}_\phi(\check{\varrho}) \exp^{il_\phi(\check{\varrho})} \rangle) : \check{\varrho} \in H\}$$

2. Represent the CSpFSS $\tilde{\mathfrak{S}}$ in matrix notation $\tilde{\mathfrak{S}}_{(p \times q)}$, $p, q \in N$, where p and q are the quantity of set of attributes and initial space of objects respectively.

$$\tilde{\mathfrak{S}}_{(p \times q)} =$$

$$\tilde{\mathfrak{S}}_{(p \times q)} = \begin{pmatrix} \check{\varrho}_{11} & \check{\varrho}_{12} & \dots & \check{\varrho}_{1q} \\ \check{\varrho}_{21} & \check{\varrho}_{22} & \dots & \check{\varrho}_{2q} \\ \check{\varrho}_{31} & \check{\varrho}_{32} & \dots & \check{\varrho}_{3q} \\ \vdots & \vdots & \ddots & \vdots \\ \check{\varrho}_{p1} & \check{\varrho}_{p2} & \dots & \check{\varrho}_{pq} \end{pmatrix}$$

where

$$\check{\varrho}_{11} = \langle \mathfrak{I}_+(\check{h}_1)(\check{\varrho}_1) \exp^{il_+(\check{h}_1)(\check{\varrho}_1)}, \mathfrak{I}_-(\check{h}_1)(\check{\varrho}_1) \exp^{il_-(\check{h}_1)(\check{\varrho}_1)}, \mathfrak{I}_\phi(\check{h}_1)(\check{\varrho}_1) \exp^{il_\phi(\check{h}_1)(\check{\varrho}_1)} \rangle$$

$$\check{\varrho}_{12} = \langle \mathfrak{I}_+(\check{h}_1)(\check{\varrho}_2) \exp^{il_+(\check{h}_1)(\check{\varrho}_2)}, \mathfrak{I}_-(\check{h}_1)(\check{\varrho}_2) \exp^{il_-(\check{h}_1)(\check{\varrho}_2)}, \mathfrak{I}_\phi(\check{h}_1)(\check{\varrho}_2) \exp^{il_\phi(\check{h}_1)(\check{\varrho}_2)} \rangle$$

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$$\check{\varrho}_{1q} = \langle \mathfrak{I}_+(\check{h}_1)(\check{\varrho}_q) \exp^{il_+(\check{h}_1)(\check{\varrho}_q)}, \mathfrak{I}_-(\check{h}_1)(\check{\varrho}_q) \exp^{il_-(\check{h}_1)(\check{\varrho}_q)}, \mathfrak{I}_\phi(\check{h}_1)(\check{\varrho}_q) \exp^{il_\phi(\check{h}_1)(\check{\varrho}_q)} \rangle$$

$$\check{\varrho}_{21} = \langle \mathfrak{I}_+(\check{h}_2)(\check{\varrho}_1) \exp^{il_+(\check{h}_2)(\check{\varrho}_1)}, \mathfrak{I}_-(\check{h}_2)(\check{\varrho}_1) \exp^{il_-(\check{h}_2)(\check{\varrho}_1)}, \mathfrak{I}_\phi(\check{h}_2)(\check{\varrho}_1) \exp^{il_\phi(\check{h}_2)(\check{\varrho}_1)} \rangle$$

$$\check{\varrho}_{22} = \langle \mathfrak{I}_+(\check{h}_2)(\check{\varrho}_2) \exp^{il_+(\check{h}_2)(\check{\varrho}_2)}, \mathfrak{I}_-(\check{h}_2)(\check{\varrho}_2) \exp^{il_-(\check{h}_2)(\check{\varrho}_2)}, \mathfrak{I}_\phi(\check{h}_2)(\check{\varrho}_2) \exp^{il_\phi(\check{h}_2)(\check{\varrho}_2)} \rangle$$

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$$\check{\varrho}_{2q} = \langle \mathfrak{I}_+(\check{h}_2)(\check{\varrho}_q) \exp^{il_+(\check{h}_2)(\check{\varrho}_q)}, \mathfrak{I}_-(\check{h}_2)(\check{\varrho}_q) \exp^{il_-(\check{h}_2)(\check{\varrho}_q)}, \mathfrak{I}_\phi(\check{h}_2)(\check{\varrho}_q) \exp^{il_\phi(\check{h}_2)(\check{\varrho}_q)} \rangle$$

$$\check{\varrho}_{31} = \langle \mathfrak{I}_+(\check{h}_3)(\check{\varrho}_1) \exp^{il_+(\check{h}_3)(\check{\varrho}_1)}, \mathfrak{I}_-(\check{h}_3)(\check{\varrho}_1) \exp^{il_-(\check{h}_3)(\check{\varrho}_1)}, \mathfrak{I}_\phi(\check{h}_3)(\check{\varrho}_1) \exp^{il_\phi(\check{h}_3)(\check{\varrho}_1)} \rangle$$

$$\check{\varrho}_{32} = \langle \mathfrak{I}_+(\check{h}_3)(\check{\varrho}_2) \exp^{il_+(\check{h}_3)(\check{\varrho}_2)}, \mathfrak{I}_-(\check{h}_3)(\check{\varrho}_2) \exp^{il_-(\check{h}_3)(\check{\varrho}_2)}, \mathfrak{I}_\phi(\check{h}_3)(\check{\varrho}_2) \exp^{il_\phi(\check{h}_3)(\check{\varrho}_2)} \rangle$$

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$$\check{\varrho}_{3q} = \langle \mathfrak{I}_+(\check{h}_3)(\check{\varrho}_q) \exp^{il_+(\check{h}_3)(\check{\varrho}_q)}, \mathfrak{I}_-(\check{h}_3)(\check{\varrho}_q) \exp^{il_-(\check{h}_3)(\check{\varrho}_q)}, \mathfrak{I}_\phi(\check{h}_3)(\check{\varrho}_q) \exp^{il_\phi(\check{h}_3)(\check{\varrho}_q)} \rangle$$

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$$\varrho_{pq} = \langle \Im_+(h_p)(\check{\varrho}_q) \exp^{il_+(h_p)(\check{\varrho}_q)}, \Im_-(h_p)(\check{\varrho}_q) \exp^{il_-(h_p)(\check{\varrho}_q)}, \Im_\phi(h_p)(\check{\varrho}_q) \exp^{il_\phi(h_p)(\check{\varrho}_q)} \rangle$$

3. Transform the matrix $\check{\mathfrak{S}}_{(p \times q)}$ into core matrix $\check{\mathfrak{S}}_{(p \times q)}^{core}$

$$\check{\mathfrak{S}}_{(p \times q)}^{core} = \begin{pmatrix} \check{\varrho}_{11} & \check{\varrho}_{12} & \cdots & \check{\varrho}_{1q} \\ \check{\varrho}_{21} & \check{\varrho}_{22} & \cdots & \check{\varrho}_{2q} \\ \check{\varrho}_{31} & \check{\varrho}_{32} & \cdots & \check{\varrho}_{3q} \\ \vdots & \vdots & \ddots & \vdots \\ \check{\varrho}_{p1} & \check{\varrho}_{p2} & \cdots & \check{\varrho}_{pq} \end{pmatrix}$$

here

$$\check{\varrho}_{11} = \langle |(\Im_+(h_1)(\check{\varrho}_1))^2 + (\Im_-(h_1)(\check{\varrho}_1))^2 - (\Im_\phi(h_1)(\check{\varrho}_1))^2| \exp^{i[(l_+(h_1)(\check{\varrho}_1))^2 + (l_-(h_1)(\check{\varrho}_1))^2 - (l_\phi(h_1)(\check{\varrho}_1))^2]} \rangle$$

$$\check{\varrho}_{12} = \langle |(\Im_+(h_1)(\check{\varrho}_2))^2 + (\Im_-(h_1)(\check{\varrho}_2))^2 - (\Im_\phi(h_1)(\check{\varrho}_2))^2| \exp^{i[(l_+(h_1)(\check{\varrho}_2))^2 + (l_-(h_1)(\check{\varrho}_2))^2 - (l_\phi(h_1)(\check{\varrho}_2))^2]} \rangle$$

$$\check{\varrho}_{1q} = \langle |(\Im_+(h_1)(\check{\varrho}_q))^2 + (\Im_-(h_1)(\check{\varrho}_q))^2 - (\Im_\phi(h_1)(\check{\varrho}_q))^2| \exp^{i[(l_+(h_1)(\check{\varrho}_q))^2 + (l_-(h_1)(\check{\varrho}_q))^2 - (l_\phi(h_1)(\check{\varrho}_q))^2]} \rangle$$

$$\check{\varrho}_{21} = \langle |(\Im_+(h_2)(\check{\varrho}_1))^2 + (\Im_-(h_2)(\check{\varrho}_1))^2 - (\Im_\phi(h_2)(\check{\varrho}_1))^2| \exp^{i[(l_+(h_2)(\check{\varrho}_1))^2 + (l_-(h_2)(\check{\varrho}_1))^2 - (l_\phi(h_2)(\check{\varrho}_1))^2]} \rangle$$

$$\check{\varrho}_{22} = \langle |(\Im_+(h_2)(\check{\varrho}_2))^2 + (\Im_-(h_2)(\check{\varrho}_2))^2 - (\Im_\phi(h_2)(\check{\varrho}_2))^2| \exp^{i[(l_+(h_2)(\check{\varrho}_2))^2 + (l_-(h_2)(\check{\varrho}_2))^2 - (l_\phi(h_2)(\check{\varrho}_2))^2]} \rangle$$

$$\check{\varrho}_{2q} = \langle |(\Im_+(h_2)(\check{\varrho}_q))^2 + (\Im_-(h_2)(\check{\varrho}_q))^2 - (\Im_\phi(h_2)(\check{\varrho}_q))^2| \exp^{i[(l_+(h_2)(\check{\varrho}_q))^2 + (l_-(h_2)(\check{\varrho}_q))^2 - (l_\phi(h_2)(\check{\varrho}_q))^2]} \rangle$$

$$\check{\varrho}_{31} = \langle |(\Im_+(h_3)(\check{\varrho}_1))^2 + (\Im_-(h_3)(\check{\varrho}_1))^2 - (\Im_\phi(h_3)(\check{\varrho}_1))^2| \exp^{i[(l_+(h_3)(\check{\varrho}_1))^2 + (l_-(h_3)(\check{\varrho}_1))^2 - (l_\phi(h_3)(\check{\varrho}_1))^2]} \rangle$$

$$\check{\varrho}_{32} = \langle |(\Im_+(h_3)(\check{\varrho}_2))^2 + (\Im_-(h_3)(\check{\varrho}_2))^2 - (\Im_\phi(h_3)(\check{\varrho}_2))^2| \exp^{i[(l_+(h_3)(\check{\varrho}_2))^2 + (l_-(h_3)(\check{\varrho}_2))^2 - (l_\phi(h_3)(\check{\varrho}_2))^2]} \rangle$$

Online ISSN

3007-3197

Print ISSN

3007-3189

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$$\check{\varrho}_{3q} = \langle |(\Im_+(h_3)(\check{\varrho}_q))^2 + (\Im_-(h_3)(\check{\varrho}_q))^2 - (\Im_\phi(h_3)(\check{\varrho}_q))^2| \exp^{i(l_+(h_3)(\check{\varrho}_q))^2 + (l_-(h_3)(\check{\varrho}_q))^2 - (l_\phi(h_3)(\check{\varrho}_q))^2} | \rangle$$

$$\check{\varrho}_{p1} = \langle |(\Im_+(h_p)(\check{\varrho}_1))^2 + (\Im_-(h_p)(\check{\varrho}_1))^2 - (\Im_\phi(h_p)(\check{\varrho}_1))^2| \exp^{i(l_+(h_p)(\check{\varrho}_1))^2 + (l_-(h_p)(\check{\varrho}_1))^2 - (l_\phi(h_p)(\check{\varrho}_1))^2} | \rangle$$

$$\check{\varrho}_{p2} = \langle |(\Im_+(h_p)(\check{\varrho}_2))^2 + (\Im_-(h_p)(\check{\varrho}_2))^2 - (\Im_\phi(h_p)(\check{\varrho}_2))^2| \exp^{i(l_+(h_p)(\check{\varrho}_2))^2 + (l_-(h_p)(\check{\varrho}_2))^2 - (l_\phi(h_p)(\check{\varrho}_2))^2} | \rangle$$

$$\check{\varrho}_{pq} = \langle |(\Im_+(h_p)(\check{\varrho}_q))^2 + (\Im_-(h_p)(\check{\varrho}_q))^2 - (\Im_\phi(h_p)(\check{\varrho}_q))^2| \exp^{i(l_+(h_p)(\check{\varrho}_q))^2 + (l_-(h_p)(\check{\varrho}_q))^2 - (l_\phi(h_p)(\check{\varrho}_q))^2} | \rangle$$

4. Split the core matrix $\check{\mathbb{S}}_{(p \times q)}^{core}$ into core matrix for amplitude $\check{\mathbb{S}}_{amp}^{core}$ terms and core matrix for phase term $\check{\mathbb{S}}_{pha}^{core}$ as given below

$$\check{\mathbb{S}}_{amp}^{core} = \begin{pmatrix} \check{\varrho}_{11} & \check{\varrho}_{12} & \dots & \check{\varrho}_{1q} \\ \check{\varrho}_{21} & \check{\varrho}_{22} & \dots & \check{\varrho}_{2q} \\ \check{\varrho}_{31} & \check{\varrho}_{32} & \dots & \check{\varrho}_{3q} \\ \vdots & \vdots & \ddots & \vdots \\ \check{\varrho}_{p1} & \check{\varrho}_{p2} & \dots & \check{\varrho}_{pq} \end{pmatrix}$$

where $\check{\varrho}_{st} = \Im_+(h_s)(\check{\varrho}_t)$, $s \in \{1, 2, 3, \dots, p\}$, $t \in \{1, 2, 3, \dots, q\}$ and

$$\check{\mathbb{S}}_{pha}^{core} = \begin{pmatrix} \check{\varrho}_{11}'' & \check{\varrho}_{12}'' & \dots & \check{\varrho}_{1q}'' \\ \check{\varrho}_{21}'' & \check{\varrho}_{22}'' & \dots & \check{\varrho}_{2q}'' \\ \check{\varrho}_{31}'' & \check{\varrho}_{32}'' & \dots & \check{\varrho}_{3q}'' \\ \vdots & \vdots & \ddots & \vdots \\ \check{\varrho}_{p1}'' & \check{\varrho}_{p2}'' & \dots & \check{\varrho}_{pq}'' \end{pmatrix}$$

where $\check{\varrho}_{st}'' = l(h_s)(\check{\varrho}_t)$, $s \in \{1, 2, 3, \dots, p\}$, $t \in \{1, 2, 3, \dots, q\}$.

5. Compute maximum decision value $D_{amp}^{max}(\check{\varrho}_m)$, minimum decision value $D_{amp}^{min}(\check{\varrho}_m)$, and score value $\odot_{amp}(\check{\varrho}_m)$ for each alternative $(\check{\varrho}_m)$, $m \in \{1, 2, 3, \dots, q\}$ from matrix $\check{\mathbb{S}}_{amp}^{core}$. Similarly compute the same value $D_{pha}^{max}(\check{\varrho}_m)$, minimum decision value $D_{pha}^{min}(\check{\varrho}_m)$, and score value $\odot_{pha}(\check{\varrho}_m)$ for each alternative $(\check{\varrho}_m)$, $m \in \{1, 2, 3, \dots, q\}$ from matrix $\check{\mathbb{S}}_{pha}^{core}$ by using the following

$$D_{amp}^{max}(\check{\varrho}_m) = \sum_{s=1}^p (1 - \Im(h_s)(\check{\varrho}_m))^2.$$

$$D_{amp}^{min}(\check{\varrho}_m) = \sum_{s=1}^p (\Im(h_s)(\check{\varrho}_m))^2.$$

$$\odot_{amp}(\check{\varrho}_m) = \frac{D_{amp}^{max}(\check{\varrho}_m) + D_{amp}^{min}(\check{\varrho}_m)}{m}$$

$$D_{pha}^{max}(\check{\varrho}_m) = \sum_{s=1}^p (1 - l(\check{h}_s)(\check{\varrho}_m))^2.$$

$$D_{pha}^{min}(\check{\varrho}_m) = \sum_{s=1}^p (l(\check{h}_s)(\check{\varrho}_m))^2.$$

$$\odot_{pha}(\check{\varrho}_m) = \frac{D_{pha}^{max}(\check{\varrho}_m) + D_{pha}^{min}(\check{\varrho}_m)}{m}$$

6. Compute mean $\odot_{amp}$ by using the following formula:

$$\odot_{amp} = \frac{S_{amp}(\check{\varrho}_m) + S_{amp}(\check{\varrho}_m)}{2}$$

4. Application

The purpose of this part is to describe the suggested algorithm using the MADAM-based context that is presented in the example that follows.

4.1. Case study

Assume that NAS Real Estate, a real estate corporation, want to begin a new building project. The company's managing director (MD) is extremely worried about the substandard building materials offered in the market. As a result, the MD has chosen to use a supplier in this regard. Two internal Companies A and B are set up for the Supplier process. Committee A is responsible for the first round of supplier screening, whereas Committee B is responsible for the suppliers final ranking and additional assessment. The company A has short listed four Supplier initially, denotes as $\{\check{\varrho}_1, \check{\varrho}_2, \check{\varrho}_3, \check{\varrho}_4\}$. Company B has mentioned four attributes for evaluating these suppliers: quality and reliability ($\check{e}_1$), cost effectiveness ($\check{e}_2$), service ($\check{e}_3$) and processing ($\check{e}_4$). By taking into account the characteristics, the committee B specialists offer their thoughts on a potential replacement in terms of CSFSS. The process of the suggested Algorithm 1 is followed in order to finish the evaluation of providers.

$$\check{S}_{(4 \times 4)} = \begin{pmatrix} \check{\varrho}_{11} & \check{\varrho}_{12} & \check{\varrho}_{13} & \check{\varrho}_{14} \\ \check{\varrho}_{21} & \check{\varrho}_{22} & \check{\varrho}_{23} & \check{\varrho}_{24} \\ \check{\varrho}_{31} & \check{\varrho}_{32} & \check{\varrho}_{33} & \check{\varrho}_{34} \\ \check{\varrho}_{41} & \check{\varrho}_{42} & \check{\varrho}_{43} & \check{\varrho}_{44} \end{pmatrix}$$

Online ISSN

3007-3197

Print ISSN

3007-3189

<http://amresearchreview.com/index.php/Journal/about>

where

$$\begin{aligned}\varrho_{11}^{\check{}} &= \langle .2e^{2i\pi(.13)}, .5e^{2i\pi(.23)}, .8e^{2i\pi(.34)} \rangle, \varrho_{12}^{\check{}} &= \langle .4e^{2i\pi(.25)}, .6e^{2i\pi(.30)}, .5e^{2i\pi(.13)} \rangle, \\ \varrho_{13}^{\check{}} &= \langle .4e^{2i\pi(.12)}, .32e^{2i\pi(.26)}, .4e^{2i\pi(.52)} \rangle, \varrho_{14}^{\check{}} &= \langle .5e^{2i\pi(.16)}, .4e^{2i\pi(.23)}, .6e^{2i\pi(.45)} \rangle, \\ \varrho_{21}^{\check{}} &= \langle .32e^{2i\pi(.19)}, .6e^{2i\pi(.43)}, .4e^{2i\pi(.23)} \rangle, \varrho_{22}^{\check{}} &= \langle .4e^{2i\pi(.45)}, .5e^{2i\pi(.53)}, .46e^{2i\pi(.42)} \rangle, \\ \varrho_{23}^{\check{}} &= \langle .6e^{2i\pi(.41)}, .16e^{2i\pi(.67)}, .6e^{2i\pi(.24)} \rangle, \varrho_{24}^{\check{}} &= \langle .7e^{2i\pi(.22)}, .4e^{2i\pi(.27)}, .32e^{2i\pi(.47)} \rangle, \\ \varrho_{31}^{\check{}} &= \langle .32e^{2i\pi(.36)}, .24e^{2i\pi(.52)}, .6e^{2i\pi(.64)} \rangle, \varrho_{32}^{\check{}} &= \langle .8e^{2i\pi(.23)}, .3e^{2i\pi(.41)}, .2e^{2i\pi(.52)} \rangle, \\ \varrho_{33}^{\check{}} &= \langle .26e^{2i\pi(.41)}, .3e^{2i\pi(.41)}, .2e^{2i\pi(.52)} \rangle, \varrho_{34}^{\check{}} &= \langle .6e^{2i\pi(.43)}, .4e^{2i\pi(.13)}, .32e^{2i\pi(.19)} \rangle, \\ \varrho_{41}^{\check{}} &= \langle .42e^{2i\pi(.31)}, .64e^{2i\pi(.42)}, .32e^{2i\pi(.53)} \rangle, \varrho_{42}^{\check{}} &= \langle .5e^{2i\pi(.22)}, .6e^{2i\pi(.63)}, .6e^{2i\pi(.33)} \rangle, \\ \varrho_{43}^{\check{}} &= \langle .32e^{2i\pi(.12)}, .32e^{2i\pi(.26)}, .4e^{2i\pi(.52)} \rangle, \varrho_{44}^{\check{}} &= \langle .4e^{2i\pi(.32)}, .6e^{2i\pi(.44)}, .42e^{2i\pi(.55)} \rangle.\end{aligned}$$

Step(3): The core matrix $\check{\check{S}}_{(4 \times 4)}^{core}$ from the above matrix $\check{S}_{(4 \times 4)}$ is

$$\check{\check{S}}_{(4 \times 4)}^{core} = \begin{pmatrix} \langle .43e^{2i\pi(.0796)} \rangle & \langle .05e^{2i\pi(.106)} \rangle & \langle .2176e^{2i\pi(.2172)} \rangle & \langle .3996e^{2i\pi(.1752)} \rangle \\ \langle (.0976)e^{2i\pi(.0959)} \rangle & \langle .1216e^{2i\pi(.098)} \rangle & \langle .6944e^{2i\pi(.2232)} \rangle & \langle .4324e^{2i\pi(.1964)} \rangle \\ \langle .4048e^{2i\pi(.2617)} \rangle & \langle .59e^{2i\pi(.1552)} \rangle & \langle .2756e^{2i\pi(.0844)} \rangle & \langle .52e^{2i\pi(.2041)} \rangle \\ \langle .1308e^{2i\pi(.2006)} \rangle & \langle .25e^{2i\pi(.2271)} \rangle & \langle .3776e^{2i\pi(.0367)} \rangle & \langle .0236e^{2i\pi(.2113)} \rangle \end{pmatrix}$$

Step (4): The core matrix is separated into core matrix for amplitude terms $\check{\check{S}}_{amp}^{core}$ and core matrix for phase term $\check{\check{S}}_{pha}^{core}$ is given

$$\check{\check{S}}_{amp}^{core} = \begin{pmatrix} .43 & .05 & .2176 & .3996 \\ .0976 & .1216 & .6944 & .4324 \\ .4048 & .59 & .2756 & .52 \\ .1308 & .25 & .3776 & .0236 \end{pmatrix}$$

and

$$\check{\check{S}}_{pha}^{core} = \begin{pmatrix} .0796 & .106 & .2172 & .1752 \\ .0959 & .098 & .2232 & .1964 \\ .2617 & .1552 & .0844 & .2041 \\ .2006 & .2271 & .0367 & .2113 \end{pmatrix}$$

(Step 5:) Compute maximum decision value $D_{amp}^{max}(\varrho_m^{\check{}})$, minimum decision value $D_{amp}^{min}(\varrho_m^{\check{}})$, and score value $\odot_{amp}(\varrho_m^{\check{}})$ for each alternative $(\varrho_m^{\check{}})$, $m \in \{1, 2, 3, \dots, q\}$ from matrix $\check{\check{S}}_{amp}^{core}$. Similarly compute the same value $D_{pha}^{max}(\varrho_m^{\check{}})$, minimum decision value $D_{pha}^{min}(\varrho_m^{\check{}})$, and score value $\odot_{pha}(\varrho_m^{\check{}})$ for each alternative $(\varrho_m^{\check{}})$, $m \in \{1, 2, 3, \dots, q\}$ from matrix $\check{\check{S}}_{pha}^{core}$ and (Step 6:) The average score value $\odot(\varrho_m^{\check{}})$ is calculated.

(Step 7:) As $\varrho_1^{\check{}}$ has maximum value 1.559, so it is the best choice.

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3007-3197

Print ISSN

3007-3189

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$\check{S}_{amp}^{core}$	$\check{\varrho}_1$	$\check{\varrho}_2$	$\check{\varrho}_3$	$\check{\varrho}_4$
$D_{amp}^{max}(\check{\varrho}_m)$	1.548	1.188	1.278	1.789
$D_{amp}^{min}(\check{\varrho}_m)$	1.835	1.018	0.846	0.271
$\odot_{amp}(\check{\varrho}_m)$	1.6915	1.103	1.062	1.03

TABLE 1. Greatest values , lowest values and Score values for amp

$\check{S}_{pha}^{core}$	$\check{\varrho}_1$	$\check{\varrho}_2$	$\check{\varrho}_3$	$\check{\varrho}_4$
$D_{pha}^{max}(\check{\varrho}_m)$	2.134	1.395	1.196	1.486
$D_{pha}^{min}(\check{\varrho}_m)$	0.723	0.107	0.863	0.271
$\odot_{pha}(\check{\varrho}_m)$	1.428	0.751	1.389	1.757

TABLE 2. Greatest values , lowest values and Score values for pha

	$\check{\varrho}_1$	$\check{\varrho}_2$	$\check{\varrho}_3$	$\check{\varrho}_4$
$\odot(\check{\varrho}_m)$	1.559	0.927	1.211	1.394

TABLE 3. Average score

5. Sensitivity Analysis

Any algorithmic model must be tested for behavior under various statistical assumptions in order to be considered reliable. A methodical approach to evaluating the durability of the obtained conclusions is sensitivity analysis. A sensitivity study is carried out using several statistical methods to confirm the suggested algorithm's robustness. With respect to this, statistical metrics like the geometric mean (G.M.), harmonic mean (H.M.). The given algo-

Methods	$\odot(\check{\varrho}_1)$	$\odot(\check{\varrho}_2)$	$\odot(\check{\varrho}_3)$	$\odot(\check{\varrho}_4)$	Ranking
A.M	1.56	.927	1.211	1.394	$\check{\varrho}_2 < \check{\varrho}_3 < \check{\varrho}_4 < \check{\varrho}_1$
G.M	1.55	.910	1.215	1.345	$\check{\varrho}_2 < \check{\varrho}_3 < \check{\varrho}_4 < \check{\varrho}_1$
H.M	1.55	.894	1.203	1.298	$\check{\varrho}_2 < \check{\varrho}_3 < \check{\varrho}_4 < \check{\varrho}_1$

TABLE 4. Comparison for sensitivity analysis by using different statistical tools

rithm gives the best decision compared to the already given models and algorithm. As model present the correct answers only for fuzzy set , also model gives only for belonging vale and not belonging vales but the given algorithm present the best decision making method for complex spherical fuzzy set which contains belonging ,non belonging also neutral values.

Online ISSN

3007-3197

Print ISSN

3007-3189

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6. Conclusion and future scope

In this research complex spherical fuzzy soft set conquer the limitations of old all fuzzy set theories The algorithm is explained in a situation involving decision-making, particularly when choosing an appropriate provider to meet the materials needed for a building project. The development of CSFSS applications with settings in a range of decision-making viewpoints is part of the study's future scope. Future research can examine the integration of CSFSS with additional sophisticated analytical methods and machine learning algorithms to enhance its extrapolative control. Although experts' opinions have been taken into account in the suggested study in terms of hypothetical data, this concept might be applied in the future to analyze a case study by taking into account genuine data for the opinions of actual decision-makers.

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