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A New Group Decision Making Approach with Fuzzy SWARA and ARAS-H for Selecting Steel Products Suppliers: A Case Study

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Abstract: Due to the increasingly competitive and globalized markets, companies seek to explore new sources of competitiveness by optimizing their supply chains and their relationships with their stakeholders. Studies show that the potential gains expected by a company that is solely interested in its internal management are very limited when compared to the potential gains throughout the supply chain. The Third Party Logistic (3PL) is chosen in this case to take charge of part or all of the logistics of the company. The terminology third party is due to the fact that is not the logistics provider who owns the products but participates in the supply chain at the points between the manufacturer and the user of a given product does. Currently, in a group decision-making context, choosing the most suitable 3PL supplier is a major challenge. In practice, some decision makers (DMs) intervene in the selection of 3PL suppliers, and each has their own perspective and wants to consider criteria that are not generally the same for all DMs. In this case study, we have coupled the Fuzzy SWARA (Step-wise Weight Assessment Ratio Analysis) method with ARAS-H (Hierarchical Additive Ratio Assessment). The main goal is to improve the decision-making process, build more efficient models and meet the needs of DMs. The proposed model is used to solve the 3PL problem of a company selling steel products.

Keywords: Group Decision Support, 3PLs Suppliers, Fuzzy SWARA, ARAS-H, Multiple Criteria Decision Making

1. Introduction

Multi-criteria group decision making (MGDM) is an important part of modern decision science due to it's ability to respond to market changes. This notable energy of the economic environment appears to involve ever-increasing capacity to adapt and respond to organizational actors. Certainly, the fast-tracked upgradeability of markets has a direct impact on the necessary responsiveness of companies. The company's adaptation and responsiveness depend on its ability to interact effectively with all stakeholders [4]. Ranking 3PL suppliers presents the most critical activity in the supply chain due to its important role and ease of operation of the chain [10]. Group decision making is difficult due to the fact that different criteria must be taken into consideration in the decision-making process. This attracts many researchers; many approaches have been proposed in the literature.

The remainder of this article is divided into three sections: Section 2 presents a literature review of the main research articles dealing with this problem and describes a comparative study of the main existing methods. Section 3 presents the proposed method to solve the 3PL supplier choice problem with a solution of a practical case. Section 4 contains conclusions.

2. Literature Review

One of the strategic decisions that has a substantial impact on company performance is ranking 3PL suppliers. As production processes evolve, this decision becomes increasingly critical. In the literature, several group decision support strategies for the challenge of selecting and ranking

3PL vendors have been developed. We organize these approaches according to their techniques: artificial intelligence, total cost-based methods, mathematical programming models, linear weighted models, and ranking methods.

2.1. Group Decision Making

Recently, the use of group decision-making has been felt in companies that have realized that traditional decision-making models adapted to the single decision-maker case no longer correspond to the organizational reality. Indeed, this decision-making deals with processes in which several decision-makers are involved, with diverging or even conflicting interests and taking a more or less direct part in the final decision.

Group Decision Making (GDM) is developed by groups of decision makers and aims to integrate group intelligence to make decisions about alternatives [13, 32, 16]. GDM has found its place in the industry as a solution to the increasing complexity of modern environments which are directly related to the decision-making problems in which technical groups make decisions on product design, progress of plans and strategies, and in the service sector such as healthcare, where critical decisions are made by a group of advisers and experts [1]. The GDM process generally starts with identifying the characteristics of the problem, including alternatives, criteria related to the alternatives, and their importance (weights), as well as Decision Makers (DMs) and stakeholders. During this stage, compromising among DMs to have an agreement over the mentioned features is highly essential and GDM can involves many complex and conflicting aspects intrinsic to human individuality and human nature [25]. GDM process usually includes the opinions of DMs who have different backgrounds and knowledge bases. As a result, interpreting and analyzing the preferences of these DMs is a complex task compared to single DM processes [35]. In decision science, GDM is an important part and plays a critical role in human life, regardless if people are carrying out daily activities, professional or political work. It can be considered as a situation in which DMs need to obtain the best solution from a set of alternatives considering their preferences and opinions [33]. The final solution is no longer attributable to a single DM, but is a responsibility of a whole group. GDM has attracted much attention from theoretical and practical points of view and has become a hot topic in decision science domain [24]. The advantage of GDM is that evaluations of the alternatives given by a group of DMs is more accurate than from a single DM in considering all significant aspects of selection problems in complex environments. Thus, GDM can often be a better option to reduce biased evaluations and the inherent partiality in decision processes [3].

2.2. Existing Methods to Select 3PL

Several ranking methods have been developed, ranging from simple single-objective methods to complex multi-objective methods. Kahraman et al. suggested a solution based on fuzzy Analytic Hierarchy Process (AHP) to handle the problem of unit site selection in supply chains [17]. Bozdag et al. used a fuzzy analytic hierarchy technique to pick the optimum production system in the same setting [2]. Because the comparison process is ambiguous, DMs generally prefer expression interval assessments to fixed-value judgments [3]. In a fuzzy context, Kumar et al. introduced a solution based on Goal Programming (GP) [19]. Three primary factors were optimized by the authors: overall cost, number of rejected applications, and late deliveries. Various limitations apply to the set, including customer requirements, supplier capabilities, budget granted to suppliers.

Yan et al. investigates an effective strategy for evaluating 3PL service suppliers, focusing on operative competency [34]. Finally, the authors point out that the difficulty of the problem is reliant on the number of criteria and sub-criteria employed in the problem's international component. Jain et al. gives a literature review on the strategy us used to solve the problem of supplier selection [11]. They outlined all of the methods in use, as well as their benefits and drawbacks. The authors presented a system for evaluating suppliers and making decisions that is based on fuzzy "Association Rules Mining Algorithms." They defended their decision to adopt fuzzy logic by the type of the decision-making data they used, which is either qualitative or quantitative. Tanonkou et al. proposed a stochastic distribution network design problem in which decisions on 3PL supplier selection, distribution center placement, and demand area assignment are all made at the same time [31]. The goal is to solve a complicated optimization issue that involves three layers of decisions: I distribution center location selection, (ii) supplier selection, and (iii) demand area distribution assignment.

In the textile sector, Jain and Benyoucef solved a 3PL supplier selection problem [12]. The goal for the single distribution center of the chain is to select a number of suppliers, means of transportation, and storage policies. To overcome this challenge, they suggested a simulation-based optimization strategy based on multicriteria genetic algorithms. Lin et al. proposed a method for choosing suppliers that takes into account the interdependence of the selection criteria (price, quality, delivery, and technique), as well as attaining optimal order allocation among vendors [15]. The proposed method given includes two steps: To pick suppliers, i combine the Analytic Network Process (ANP) with fuzzy Preference Programming (PP) to create a more powerful fuzzy ANP (FANP); (ii) use multipurpose ANP (MANP). For the problem of supplier selection and order allocation, Mafakheri et al. proposed a two-stage dynamic multi-criteria programming technique [20]. The AHP approach is used to rate the suppliers in the first phase. The order allocation model is proposed in the second phase. Its goal is to maximize the company's service function while lowering all supply chain costs. The VIKOR method was presented by Nilay et al. [23] to tackle multiple criteria decision-making problems with contradicting and non-commensurable criteria. In Turkey, this strategy is used to select insurance businesses by investors. Devendra and Ravi presented an integer linear programming model for determining supply, lot size, suppliers, and carriers all at the same time [8]. They were tasked with using a GP-based program to solve a multiple-choice problem. Indeed, the model's goal is to identify the replenishment period's timings (moments), the amount of the batch to be acquired, and the supplier and carrier to be chosen. Data Envelopment Analysis (DEA) and Quality Function Deployment (QFD) were used by Karsak and Dursun [18] to develop a group decision-making technique. This methodology outlines the features that acquired items should have in order to suit the business's needs, and then it aims to establish the appropriate vendor's evaluation criteria. Kumar proposed a new model that combines two methods: AHP and FGP (Fuzzy GP) to allow a decision support group to identify and classify providers based on a group of DMs' preferences [19]. To overcome the problem, the author advocated combining two strategies. The first uses a fuzzy AHP and the geometric means approach to prioritize and aggregate a GDM's choices. The collected priorities were then combined with the GP in order to do discriminant analysis and come up with a solution. Sengül et al. provided a model for analyzing a multicriteria group decision framework for renewable energy supply systems in Turkey based on the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) Soft approach [29]. Chen and Zeshu proposed the Hesitant Fuzzy ELECTRE II (HF-ELECTRE II) methodology, which combines the Hesitant Fuzzy Sets (HFS) logic with the ELECTRE II method to successfully aggregate distinct group DMs' opinions [6]. In the same vein, çalik combined AHP and TOPSIS methodologies in a Pythagorean fuzzy environment to produce a novel group decision-making methodology based on Industry 4.0 components for picking the best green supplier [5]. Different experts' assessments are communicated using language phrases based on Pythagorean fuzzy numbers in the established method. Fuzzy AHP was used to calculate the criteria weights, and Fuzzy TOPSIS was used to rank the suppliers and choose the best one. Furthermore, Nakiboglu and Bulgurcu proposed an extended use of the TOPSIS method for solving a group decision-making problem of selecting the best raw material supplier for a specific Turkish textile company in an intuitionistic fuzzy (IF) environment, in which all DMs' ideas are presented as IF values [22]. Wei et al. applied the Evaluation based on Distance from Average Solution (EDAS) method to multiple criteria group decision making (MCDM) using Probabilistic Linguistic Term Sets (PLTSs) to solve environmental problems in China in order to gain a competitive market and a green image for enterprises in order to achieve long-term economic development [32].

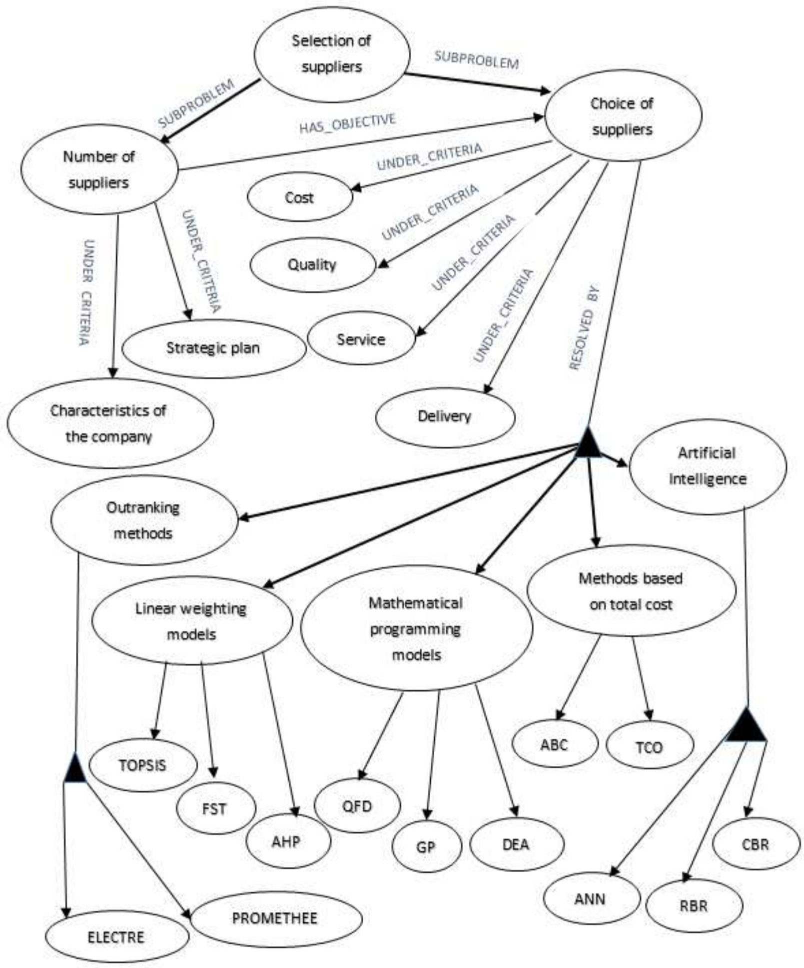

Figure 1. *Selection of suppliers Taxonomy [4].*

Figure 1 depicts the classification of the supplier problem, as well as the importance of the sub-problems and related methods.

The following Abbreviations are used

TOPSIS: Technique for Order of Preference by Similarity to Ideal Solution; *FST:* Fuzzy Set Theory; *AHP:* Analytic Hierarchy Process; *QFD:* Quality Function Deployment; *GP:* Goal Programming; *DEA:* Data Envelopment Analysis; *ABC:* Activity-Based Costing; *TCO:* Total Cost of Ownership; *ANN:* Artificial Neural Network; *CBR*: Case-Based Reasoning; *RBR:* Rule-Based Reasoning.

2.3. Determining Criteria Weights

To determine the weights of the criteria, several methods have been presented. According to Chiang [7], "determining the weights of each criterion so that all options may be evaluated based on the aggregate performance of all criteria is one of the most difficult tasks in multiple criterion decision analysis (MCDA)." Many research papers in this area focused on determining criteria weights. Figueira and Roy, for example, presented a new version of the Simos approach that incorporates a new type of DM information and corrects some calculation criteria [14]. In addition, a new tool has been built based on the improved Simos' process. Chiang also devised a relative distance metric, which involves determining an alternative's relative location between the anti-ideal and the ideal in order to find the lowest absolute distance between an alternative and the ideal, and so ranking the alternatives from best to worst [7]. The author demonstrated that, regardless of how weights are calculated, the relative distance gives consistent classification for any collection of weights. As a result, this method is appropriate for computing weights when no prior information is available. Rezaei has introduced a new method called the Best-Worst Method (BWM) [26]. First and foremost, the DM presents both the best and worst criteria. Following that, pairwise comparisons are made between these two criteria (best and worst) and the other criteria. The weights of various criteria are then determined by formulating and solving a maximin problem. Roszkowska offered a comparison of many rank ordering weight algorithms that translate the ordinal ranking of a number of criteria into numerical weights in the same context [27]. Siskos and Tsotsolas also published a set of complementary robustness analysis rules and measures that were integrated into a robust Simos technique for eliciting criteria weights [28]. The purpose was to assist the DM and analysts in understanding the whole range of weighing solutions, selecting a single set of criteria weights, and applying robust rules based on various sets of permissible weights. Finally, Mavi et al. used fuzzy SWARA (Stepwise Weight Assessment Ratio Analysis) to calculate criteria weights in order to solve a third-party reverse logistic supplier selection problem in a plastic manufacturing [21].

3. The Proposed Model

We note the complexity and difficulty of evaluating the results obtained for most of the proposed methods. The main objective is to optimize the decision-making process and to have another more efficient model and to meet the needs of the DMs. For this reason, we propose the following model which consists of a hybrid method based on the Fuzzy SWARA method and ARAS-H (Hierarchical Additive Ratio Assessment) for solving the group multicriteria decision problem.

3.1. Fuzzy SWARA

The fuzzy SWARA is one of the new methods used to rank evaluation criteria according to the degree of importance expected by decision-makers in order to determine the weight of the evaluation criteria in a fuzzy environment [30]. This method can be used to facilitate the appreciation of the preferences of DMs regarding the meaning of attributes in the weight determination process.

The steps of this method are as follows:

Step 1: Sort the evaluation criteria from maximum preference to minimum, considering the goal of decision making.

Step 2: The process is started from the second factor where the experts allocate a score between zero and one to the factor j in relation to the previous criterion ($j - 1$). This process is then applied to each factor. This ratio represents the comparative importance of $\hat{S}_j$. The values are shown in Table 3.

Step 3: Calculation of the values of the coefficient $\hat{e}_j$ as follows

$$\hat{e}_j = \begin{cases} 1, j = 1 \\ \hat{S}_j + 1, j > 1 \end{cases} \tag{1}$$

Step 4: The recalculated fuzzy weights $\hat{g}_j$.

$$\hat{g}_j = \begin{cases} 1, j = 1 \\ \frac{\hat{g}_{j-1}}{\hat{e}_j}, j > 1 \end{cases} \tag{2}$$

Step 5: The weight of fuzzy criteria $\hat{w}_j$.

$$\hat{w}_j = \frac{\hat{g}_j}{\sum_{k=1}^{n} \hat{g}_k} \tag{3}$$

Where $w_j = (l, m, u)$ is the fuzzy relative importance weight of the jth criterion and n is the number of criteria.

These fuzzy weights are converted into crisp weights (w_j) by following equation:

$$w_j = \frac{w_j^l + w_j^m + w_j^u}{3} \tag{4}$$

Moreover, let $A_1 = (l_1, m_1, u_1)\ and\ B_1 = (l_2, m_2, u_2)$.

The basic arithmetic operations on triangular fuzzy numbers (TFN) can be expressed as follows:

$$A_1 + B_1 = (l_1 + l_2, m_1 + m_2, u_1 + u_2) \qquad A_1 * B_1 = (l_1 * l_2, m_1 * m_2, u_1 * u_2)$$

$$A_1 - B_1 = (l_1 - l_2, m_1 - m_2, u_1 - u_2) \qquad A_1/B_1 = (l_1/u_2, m_1/m_2, u_1/l_2)$$

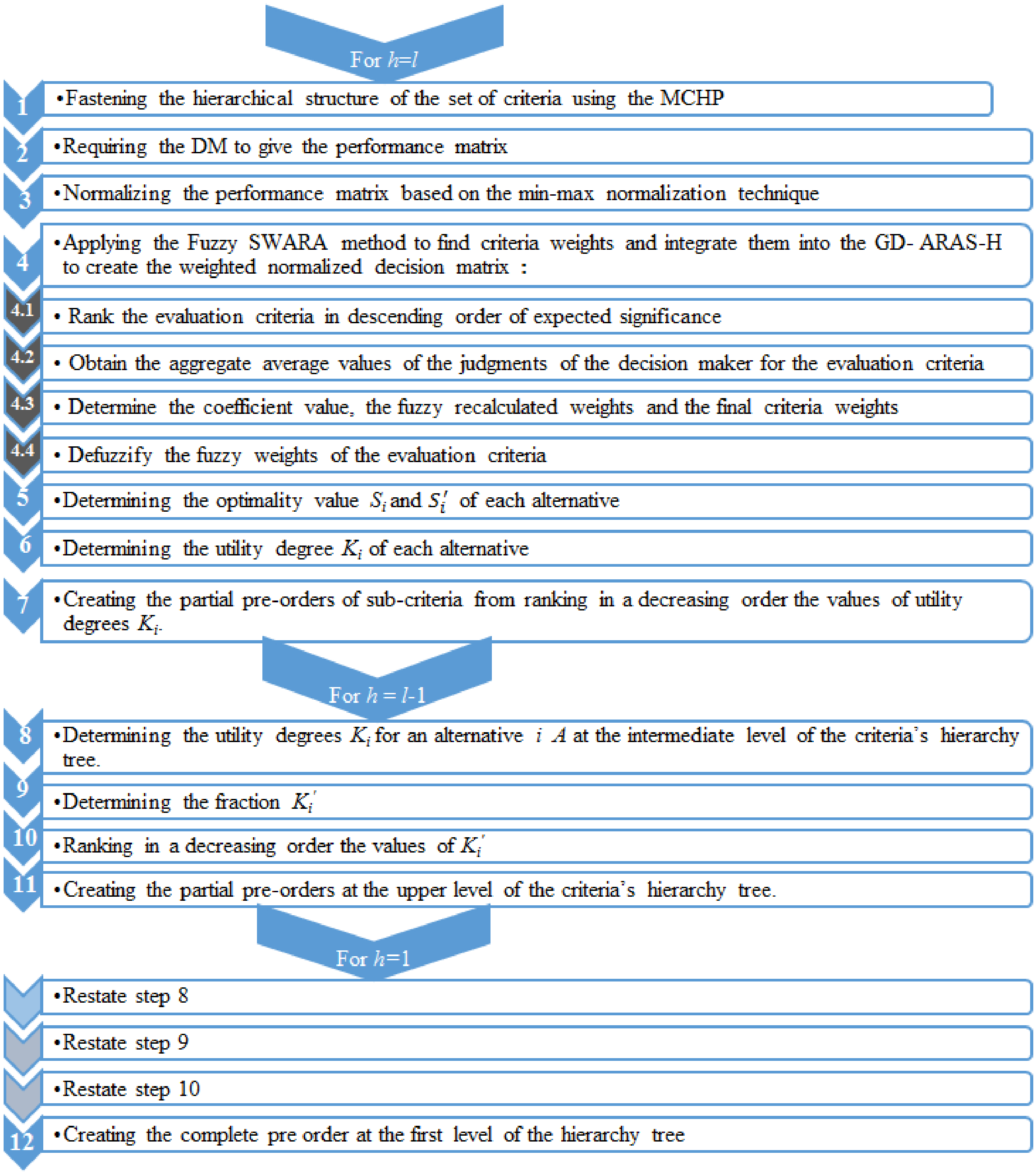

Figure 2. *A flow chart for the F-SWARA_GD-ARAS-H algorithm.*

3.2. Group Decision ARAS-H Method

The group decision ARAS-H method is an expansion of the ARAS-H method in which numerous DMs provide evaluations of options based on elementary criteria [9].

The purpose of the first stage of the GD-ARAS-H algorithm is to find the utility degrees of the alternatives based on elementary criteria from the evaluations given by DMs. Afterward, we proceed to create the partial pre orders of intermediate criteria whose only descendants are elements in the set of elementary criteria (E). Then, at the upper level of the criteria tree and for each alternative, we determine the utility degrees and ranking them in a decreasing order. Thereupon, we create the partial pre-orders according to the 1st level of intermediate criteria. The last stage of the proposed algorithm (at the first level of the hierarchy tree) consists of determining the utility degrees of the alternatives to rank them in a decreasing order to construct the complete pre order (ranking the alternatives according to the root criterion).

For $h = l$

Step 1: Fixing the hierarchical structure of the set of criteria using the MCHP (Multiple Criteria Hierarchy Process), separating the subsets of elementary criteria, and higher-level criteria, up to the root criterion.

Step 2: Requiring the DM to give the performance matrix that alternatives are evaluated based on basic criteria.

Step 3: Normalizing the performance matrix based on the min-max normalization technique.

$$\text{For criteria maximization: } \bar{x}_{ij} = \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})} \text{ i} \in \text{A and j} \in \text{EL}$$

$$\text{For criteria minimization: } \bar{x}_{ij} = \frac{\max(x_{ij}) - x_{ij}}{\max(x_{ij}) - \min(x_{ij})} \text{ i} \in \text{A and j} \in \text{EL}$$

Step 4: Constructing the weighted normalized decision matrix.

$$\hat{x}_{ij} = \bar{x}_{ij}\, w_j;\ \text{i} \in \text{A; j} \in \text{EL}$$

Step 5: Determining the optimality value S_i and S_i' of each alternative.

$$S_i = \sum_{j \in \text{EL}} \hat{x}_{ij};\ \forall \text{ i} \in \text{A}$$

$$S_i' = \frac{1}{d} \sum S_i;\ \forall \text{ i} \in \text{A}$$

Where:

d: is the number of DMs

Step 6: Determining the utility degree K_i of each alternative.

$$\text{K}_\text{i} = \frac{S_i}{S_0};\ \forall \text{ i} \in \text{A}$$

Where:

S_0 is the optimal value (presents the maximum value of S_i) and the calculated values of $K_i \in [0,1]$.

Step 7: Determining the partial pre-orders of sub-criteria from ranking in a decreasing order the values of utility degrees K_i.

For $h = l-1$

Step 8: Determining the utility degrees K_i for each alternative $i \in A$ based on each first level intermediate criterion G_f.

$$\text{K}_\text{i} = \sum_{j \in I_G} K_i \text{ w}_\text{j;}\ \forall \text{ i} \in \text{A}$$

Criteria weights are normalized such that $\sum_{j \in I_G} w_j = 1$.

Step 9: Determining the fraction $K_i' = \frac{K_i}{\sum_{i \in A} K_i}$

Step 10: Ranking in a decreasing order the values of K_i'.

Step 11: Creating the partial pre-orders at the upper level of the criteria's hierarchy tree.

For $h = 1$ (i.e., at the first level of the hierarchy tree).

Restate step 8.

Restate step 9.

Restate step 10.

Step 12: Creating the complete pre order at the first level of the hierarchy tree (i.e. ranking the alternatives based on the root criterion).

The suggested Fuzzy SWARA_GD-ARAS-H algorithm is demonstrated in the below flow chart (Figure 2).

3.3. A Case Study: Distribution of Steel Products

The novel Fuzzy Group SWARA–ARAS–H model can be used to solve a variety of issues. The case study focuses on the distribution of steel products in the Tunisian city of Sousse. The firm has long been a major provider of steel products. It has a team of about 100 employees that work in various divisions. The company's difficulty is to choose one of various vendors to use.

In this section, we address the analysis of this dataset with the hybrid approach Fuzzy SWARA_GD-ARAS-H. The Fuzzy SWARA method is for criteria weight elicitation in a fuzzy context and the group decision making ARAS-H method is for ranking the steel product suppliers according to each sub-criterion considering the assessments of three DMs.

The potential candidates are: PROSID, SOQUIBAT, SOTIC, SFAX METAL, GABES METAL, PPM, STUNAS INDUSTRIES, SUD METAL, SOFNORD, STE R2K METAL and STEL'EVOLUTION.

The figure 3 presents the hierarchical structure of criteria. The root criterion corresponds to the objective: Selection of steel product supplier. Commercial, Security, Technical, Financial and Social present the intermediate criteria. The criteria at the last level, present the elementary criteria in which the DM can directly evaluates the alternatives. All of them to be maximized except the cost to be minimized.

The experts listed the criteria according to their expected level of importance.

Table 1. *Criteria.*

Criteria	Designation	Maximize or minimize the value of the criterion (Max/Min)
Cost	C	Min
Delivery	DE	Max
Service	SCE	Max
Avaibility	AV	Max
Quality	QU	Max
Reference	RE	Max
Organisation	O	Max
Validity	V	Max
Product Certifaction	PCE	Max
Payement Condition	PC	Max
Payement Method	PM	Max
RelationShip	R	Max

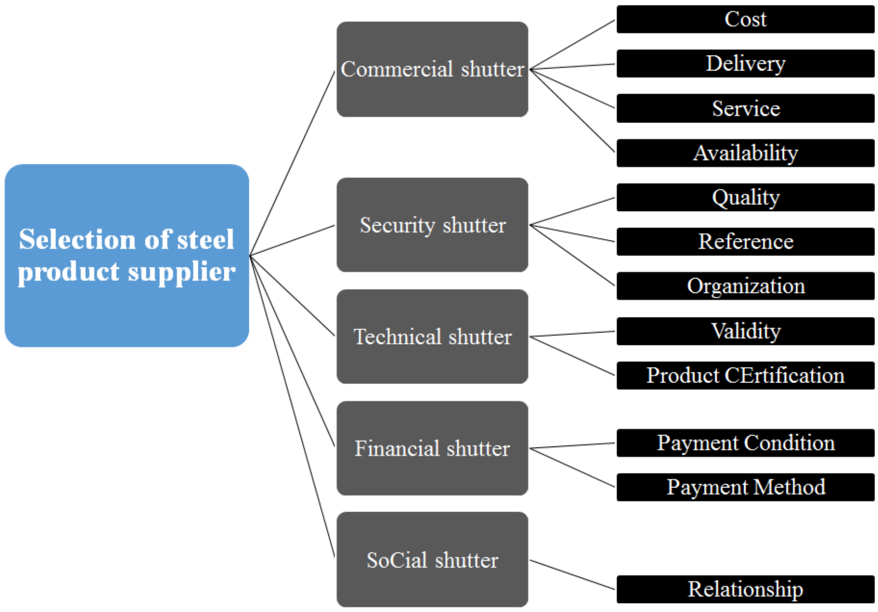

Figure 3. *The hierarchical structure of criteria.*

Table 2. *Linguistic Values by (Chang, 1996).*

Linguistic scale	Triangular Fuzzy Number (TFN)
Much Less Important	(0.222, 0.25, 0.286)
Very Less Important	(0.286, 0.333, 0.40)
Less Important	(0.4, 0.5, 0.667)
Moderately Important	(0.667, 1, 1.5)
Equally Important	(1, 1, 1)

Using the values from Table 2 and from the second criterion, the (j-1) th criterion is compared to the jth criterion. The decision-maker in this comparison uses linguistic values expressing $\hat{S}j$, which is the first step in Fuzzy SWARA. The decision maker ranks the factors in order of priority.

The DMs provided us with the following decision matrix in which each one of the experts (DMs) evaluates the alternatives according to the elementary criteria.

Table 3. *Decision Matrix.*

DM(i)	DM1											
Criteria	**CS**				**SS**			**TS**		**FS**		**SCS**
Sub Criteria	**C**	**DE**	**SCE**	**AV**	**QU**	**RE**	**O**	**V**	**PCE**	**PC**	**PM**	**R**
PROSID	0,650	0,600	7	8	7	7	8	0,900	0,900	7	7	7
SOQUIBAT	0,700	0,650	7	8	7	7	8	0,900	0,900	7	7	8
SOTIC	0,800	0,700	7	8	8	7	8	0,900	0,900	9	8	9
SFAX METAL	0,800	0,650	8	8	8	7	8	0,900	0,900	9	9	10
GABES METAL	0,400	0,600	8	7	8	6	8	0,900	0,900	9	9	9
PPM	0,500	0,700	8	8	7	7	7	0,900	0,700	6	6	6
STUNAS INDUSTRIES	0,800	0,600	9	8	8	8	8	0,900	1,000	9	9,5	8
SUD METAL	0,350	0,500	8	7	7	7	7	0,900	0,800	6	6	5
SOFNORD	0,100	0,700	8	9	7	5	6	0,800	0,400	5	5	3
STE R2K METAL	0,500	0,800	7	9	8	6	6	0,900	0,300	7	7	7
STE L'EVOLUTION	0,800	0,800	8	8	5	5	7	0,900	0,400	7	7	7

DM(i)	DM2											
Criteria	**CS**				**SS**			**TS**		**FS**		**SCS**
Sub Criteria	**C**	**DE**	**SCE**	**AV**	**QU**	**RE**	**O**	**V**	**PCE**	**PC**	**PM**	**R**
PROSID	0,700	0,550	6	7	8	9	7	0,800	0,800	7,5	8	7
SOQUIBAT	0,650	0,750	6	7	8	9	7	0,800	0,850	8	8	9
SOTIC	0,700	0,800	7	7	8	9	7	0,750	0,800	9	7	10
SFAX METAL	0,900	0,850	7,5	9	9	9	7	0,850	0,900	7,5	8	9
GABES METAL	0,800	0,500	7	6	7	5	6	0,850	0,750	8	8	8
PPM	0,400	0,500	6	5	5	4	5	0,800	0,600	5	5	5
STUNAS INDUSTRIES	1,000	0,800	9	7	9	9	9	0,800	1,000	9	9	10
SUD METAL	0,200	0,350	5	5	4	4	5	0,500	0,400	4	5	4
SOFNORD	0,100	0,400	5	2	4	4	5	0,400	0,400	3,5	3	0
STE R2K METAL	0,450	0,600	6	5	5	5	5	0,500	0,250	3,5	5	5
STE L'EVOLUTION	0,700	0,700	7	7	6	6	5	0,400	0,350	7,5	5	6

DM(i)	DM3											
Criteria	**CS**				**SS**			**TS**		**FS**		**SCS**
Sub Criteria	**C**	**DE**	**SCE**	**AV**	**QU**	**RE**	**O**	**V**	**PCE**	**PC**	**PM**	**R**
PROSID	0,550	0,700	7	6	7	8	9	0,850	0,850	6,5	8	7,5
SOQUIBAT	0,750	0,650	7	6	7	8	9	0,850	0,850	6,5	8	7,5
SOTIC	0,800	0,700	7	7	7	7	9	0,850	0,750	6,5	8	8,3
SFAX METAL	0,850	0,900	8	7,5	7	8	9	0,850	0,750	8	8	9,0
GABES METAL	0,500	0,800	8	7	5,5	8	9	0,700	0,750	9	8	9,0
PPM	0,500	0,400	8	6	5	5	5	0,750	0,650	5	8	7,0
STUNAS INDUSTRIES	0,800	0,850	9	9	9	9	9	0,950	0,850	9	9	9,5
SUD METAL	0,350	0,200	8	5	5	5	5	0,700	0,750	5	5	4,5
SOFNORD	0,400	0,100	8	5	5	3	4	0,600	0,200	5	5	4,5
STE R2K METAL	0,600	0,450	7	6	5	5	5	0,700	0,300	6	5	6,5
STE L'EVOLUTION	0,700	0,700	8	7	5	5	6	0,700	0,150	6	3,5	7,0

Table 4. *Criteria weights.*

Elementary criteria	Weights
Cost (C)	0,227
Availability (AV)	0,122
Delivery (DE)	0,084
Service (SCE)	0,064
Quality (QU)	0,100
Reference (RE)	0,069
Organization (O)	0,056
Product Certification (PCE)	0,082
Validity (V)	0,044
Payment Method (PM)	0,056
Payment Condition (PC)	0,030
Relationship (R)	0,066

Table 5. *Intermediate Criteria weights.*

Intermediate criteria	Weights
Commercial shutter (CS)	0,415
Security shutter (SS)	0,217
Technical shutter (TS)	0,165
Financial shutter (FS)	0,112
SoCial shutter (SCS)	0,091

The criteria and the intermediate criteria weights are determined by F-SWARA method.

After the construction of the normalized and the weighted normalized decision matrix, we proceed to rank the alternatives with respect to the intermediate criteria Commercial, Security, Technical, Financial and Social respectively in a decreasing order of their utility degrees.

Figure 4. *The partial pre-orders.*

Then, we determine the utility degrees of all alternatives according to the root criterion to create the complete pre-order.

Table 6. *Ranking of alternatives.*

Alternatives	K_i	K_i/sum	Rank
PROSID	0,654	0,099	4
SOQUIBAT	0,641	0,097	6
SOTIC	0,649	0,098	5
SFAX METAL	0,693	0,105	3
GABES METAL	0,737	0,111	2
PPM	0,575	0,087	7
STUNAS INDUSTRIES	0,792	0,12	1
SUD METAL	0,539	0,082	8
SOFNORD	0,458	0,069	10
STE R2K METAL	0,461	0,07	9
STE L'EVOLUTION	0,408	0,062	11
Sum	6,607		

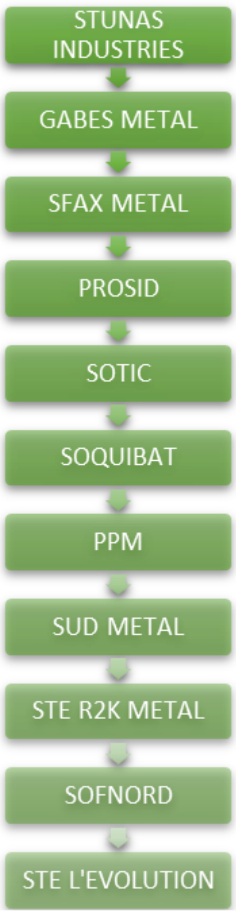

Figure 5. *The complete pre-order.*

4. Discussion

The proposed model for supplier classification is based on the decision-makers, the quantity of suppliers, and the evaluation criteria. As a result, our methodology entails categorizing steel product providers in Tunisia based on their importance and the criteria employed (C, AV, DE...). The fuzzy SWARA approach was used to determine criterion weights. Following this process, the ARAS-H technique was used to rank providers of STEEL Products. The best supplier is "STUNAS INDUSTRIES," which is followed by GABES METAL, SFAX METAL, PROSID, SOTIC, SOQUIBAT, PPM, SUD METAL, STE R2K METAL, SOFNORD, and STE L'EVOLUTION, respectively.

If we can compare the result found by ARAS-H with the result found by TOPSIS-H (figure 6), we notice that the two results are close but the TOPSIS-H procedure is more complex and more difficult and that ARAS-H can be preferable in multi-criteria problems.

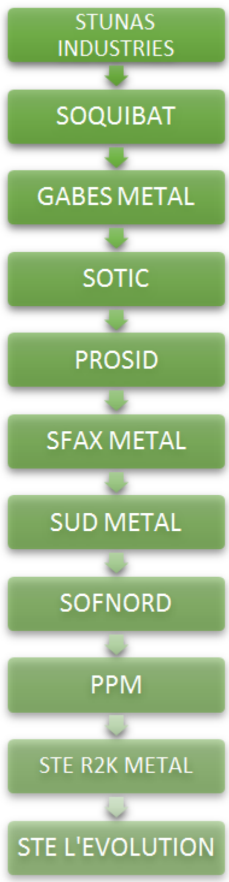

Figure 6. *Result TOPSIS-H.*

Although this issue has been dealt with extensively, it is still open to any innovation and especially in terms of the processing of the methodologies used. This research adds to the existing body of knowledge. The combination of Fuzzy SWARA and ARAS-H has not been created to our knowledge, and there is no research linked to this combination in the literature. This study will close the gap. The proposed model will be employed for the first time in this investigation.

5. Conclusion

We proposed a ranking MCDM approach based on group performance ratings in this research. Each expert (DM) in the proposed technique makes his own evaluations of alternatives based on a set of criteria. The Fuzzy SWARA method and the GD-ARAS-H method are used in the suggested strategy. The Fuzzy SWARA method is indeed utilized to calculate the criteria weights. The GD-ARAS-H approach, on the other hand, is used to rank the options. When compared to the popular F-AHP method, the Fuzzy SWARA method requires a much smaller number of pairwise comparisons. An extensive computational process is used in the GD-ARAS-H method.

When analyzing the alternatives, we take the group of DMs' consensuses into account to avoid any potential disagreement.

In future research, studies intend to include other practices in the selection criteria to further optimize the accuracy of supplier selection and may consider fuzzy values in the evaluation process, e.g., fuzzy ARAS-H and considering our method in the green supplier selection will be very effective to paying great attention to environmental factors.

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