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# A New Approach for Supplier Selection Process from the Features of Second Layer Suppliers Point of View

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## KEYWORDS

Supply Chain Management (SCM),
Supplier Selection,
Second Layer Supplier, Green Factor,
Linear Programming,
Fuzzy Set Theory

## ABSTRACT

*In nowadays world competitive market, on account of the development of electronic media and its influence on shortening distances, companies require some core competencies in order to be able to compete with numerous competitors in industry and sustain their situation in such a market. In addition companies achieve this target are those which their processes perform great and exploit from competitive price, quality, guarantee, etc. Since some parameters such as price and quality are so dependent on the performance of company supply chain management, so the results can highly impress the final price and quality of products. One of the main processes of supply chain management is supplier selection process which its accurate implementation can dramatically increase company competitiveness. In presented article two layers of suppliers have been considered as a chain of suppliers. First layer suppliers are evaluated by two groups of criteria which the first one encompasses criteria belongs to first layer suppliers features and the second group contains criteria belong to the characteristics of second layer suppliers. One of the criteria is the performance of second layer suppliers against environmental issues. Then the proposed approach is solved by a method combined of concepts of fuzzy set theory (FST) and linear programming (LP) which has been nourished by real data extracted from an engineering design and supplying parts company. At the end results reveal the high importance of considering second layer suppliers features as a criteria for selecting the best supplier.*



## 1. Introduction

Nowadays, competitive business environment has forced companies to satisfy customers who demand increasing product variety, lower cost, better quality and faster response [1]. In each manufacturing process, the decision maker is faced to lots of parameters which are involved in cost and if wants to bring the cost down, should do a tradeoff among them, therefore after the tradeoff the decision maker will be notified of those parameters that play remarkable role in increasing cost of production. One of the important cost parameters is cost of raw materials and component parts which comprise the bulk of the product cost, reaching up to 70% in some cases in most industries [2]. Meanwhile, in high-technology companies, purchased materials and services comprise up to 80% of total product cost [3]. So when the cost of raw materials or component parts dominates the product cost, supplier selection becomes a crucial process for the company to maintain or lower the cost while holding the quality of the products [4]. Among most of articles which discuss supplier

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selection an important process in supply chain management, it has been considered as an MCDM problem which contains both tangible and intangible factors. If process is done correctly, a higher quality and longer lasting relationship is more attainable [5]. In other word, selection of wrong supplier could be enough to upset the company's financial and operational position. However, selecting the right suppliers significantly reduces purchasing cost, improves competitiveness in market and enhances end user satisfaction [6].

Supplier selection is a fundamental issue in supply chain which heavily contributes to the overall supply chain performance. Supplier selection is the process by which suppliers are reviewed, evaluated and chosen to a become part of the company's supply chain [7].

In previous decades, supplier selection problem has been noticed as an important problem in both industry and science. It can result in better and more efficient services/products due to cooperating with suppliers [8-14]. Therefore, outsourcing has become the valuable procedure in business [15]. First related papers in supplier selection can be traced back to the 1950s when applications of linear programming and scientific computations were at their beginning. The first recorded supplier selection model is that used by the National Bureau of Standards in the United States of America to find the minimum cost way for awarding procurement contracts in the Department of Defense [16]. In 2001 another review was published by De Boer, Labro and Morlacchi focused on methods supporting supplier selection [17], in 2007 a comprehensive review on supplier selection and order lot sizing methods was done by Aissaoui and her colleagues [16] and at last the latest review on supplier selection was performed by William, Xiaowei and Parsanta, they review multi criteria decision making approaches for supplier evaluation and selection process [18]. Lin and Chen (2004) did a complete review of literature and identified 183 decision attributes for evaluating candidate supply chain alliances for general industries. These attributes are further categorized into eight aspects: (1) finance, (2) human resource management, (3) industrial characteristics, (4) knowledge/technology acquiring and management, (5) marketing, (6) organizational competitiveness, (7) product development, production and logistics management, and, finally, (8) relationship building and coordination. Over 50% of the evaluation attributes are focused on two last aspects [19, 5].

Besides all of the published articles about criteria of selecting best supplier, many papers have presented various methods and procedures. Most of them are MCDM methods as instance mathematical programming (MP), goal programming (GP), heuristic algorithms such as genetic algorithm (GA), etc, which all making efforts in order to simplify the process with more accuracy and also seek some objectives such as the order quantity, capacity, etc. the mathematical programming (MP) includes linear programming (LP) and combination linear programming. Goal programming (GP) has been studied by itself and applied in supplier selection by so many researchers such as Muralidharan, Weber, Kaslingam, Lee [20-23, 5]. Weber [24] developed application of DEA and used it in supplier selection process and, also, utilized a hybrid model which contained multi objective programming (MOP) and DEA. The AHP method introduced by Saaty [25], has variety applications in supplier selection process as many researchers utilized it and its derivatives like FAHP and ANP in their articles. As William mentioned in his article, AHP and ANP have been applied in ten article from 78 (about 13 percent) international journal articles which were reviewed [18]. Partovi [26], Nydick [27] and Narasimahen [28] were named as early users of AHP in supplier selection. The main cause of using AHP in such process is its simplicity in calculation and the ability of involving both qualitative and quantitative factors. Furthermore, so many hybrid methods with AHP such as combination of AHP and linear programming were illustrated by Ghodsypour [29]. Meade [30] used ANP (introduced by Saaty [25]) and multi utility theory in order to justifying of strategic alliances and partnering. Bottani [31] applied cluster analysis and AHP in order to simplifying the purchase process and selecting the best supplier.

Wan lung Ng [32] tried to select suppliers by utilizing linear programming with transformation method and compared attained results with the outcomes from DEA. Sanayei [7] not only focused on supplier selection process but also determined the order quantity among the suppliers by applying multi attribute utility theory and linear programming. Yih-Wu [4] used the Analytical Network Process (ANP) and mixed integer programming (MIP) and Delphi in order to develop a model for supplier selection process in condition of high quality and low price. Kokangul [33] utilized AHP with non linear programming and, also, multi objective programming to create a procedure to selecting supplier which contains such parameters like capacity, discount, etc. While presenting different types of supplier selection methods, a few articles can be found which applied compensatory methods for supplier selection. In presented article, by considering literature, a combinatorial method of linear programming and fuzzy set theory is applied in order to selecting suppliers. The other sections of this paper are as follows:

The proposed Framework of selecting suppliers by considering features of second layer suppliers is introduced in section 2. Section 3 is about a introducing the combinatorial method of fuzzy set theory and linear programming. Applying of aforementioned approach to a real problem and expressing the case study is in section 4 Conclusion and references are discussed in section 5 and 6 respectively.

## 2. Proposed Framework of Selecting Suppliers by Considering 2nd Layer Suppliers Features

Firstly, it is considered that there exists an industrial unit with the aim of manufacturing products (such as car, watch, and bicycle) which are final products and has the ability to be distributed directly to the market and be delivered to end users. Therefore the main manufacturer requires a procedure in order to assemble some semi final products (SFP) and components parts by utilizing some raw materials and standard parts. So the main manufacturer requirements can be divided into two categories first includes raw materials and the second contains standard parts and semi final products. Raw materials is called to those materials which are directly used in assemble lines of the main manufacturer and just have one layer of suppliers such as oil, glue, etc. the second category of suppliers are those who provide parts (in this article named as *P*). Considering the main manufacturer requires *N* parts, *N* can be separated into two groups. The first group refers to those parts which are included in standard parts and manufactured in large amounts such as screws, nuts, etc and the second group represents those parts which the amount of their production might not be the same for different products (such as brake pads and gearboxes in different vehicles) and the main focus of this article is on the parts belong to second group.

Let $n$ be a subset of $N$ that contains number of parts which are belonged to second part, then $P_i$ demonstrated the $i^{th}$ part of $n$; since there might be a supplier who is able to provide the main manufacturer more than one part from $n$ parts, therefore the main manufacturer would not need $n$ suppliers and just in an exceptional situation the existence of $n$ different suppliers will occur. Hence, suppliers in first layer can be formed into a set named "first layer suppliers set" with $m$ members ( $S_j^1$ demonstrates the $j^{th}$ supplier from $m$ first layer suppliers).

By considering the fact that manufacturing process in the place of first layer suppliers need raw materials, so each semi final products exploit some raw materials in order to be produced. Meanwhile it very common that some of the semi final products require similar raw materials, then it can be perceived that in order to provide $n$ required parts by the main manufacturer, there is a set of raw materials with $k$ members ($R_u$ represents the $u^{th}$ raw material from $k$ required raw materials). Therefore, if there exists a supplier who has the ability the provide $g$ parts from $n$ parts, and then the aforementioned supplier will require whole raw materials for producing $g$ parts.

Regarding to the concepts of first and second layer of suppliers, each supplier in first layer need some raw materials based on what he can deliver. So $S_{uj}^2$ represents $j^{th}$ second layer supplier for the $u^{th}$ raw material (Fig. 1).

The proposed model is contains four different set which are as follows:

Set of Parts: includes whole required semi final products (SFP) by main manufacturer.

Set of first layer suppliers: includes all of the supplier who are responsible of providing the SFP's for main manufacturer.

Set of raw materials: includes whole required raw materials for manufacturing set of parts.

Set of second layer suppliers: includes suppliers who are responsible of providing raw materials for first layer suppliers.

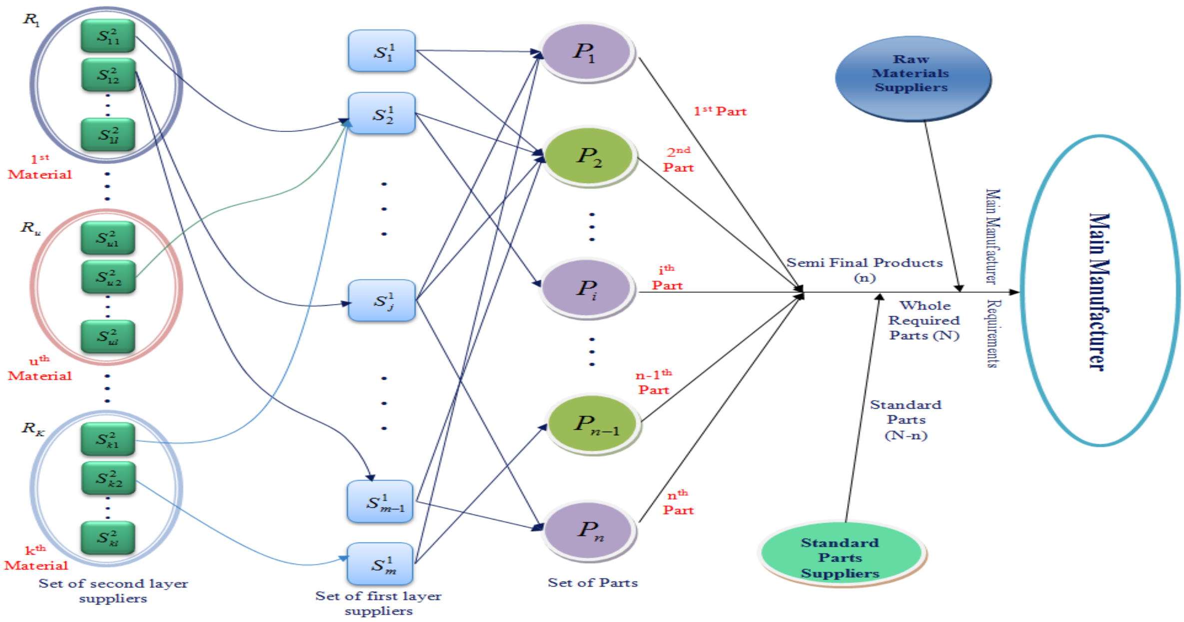


**Fig. 1. The sequence of 1st and 2nd layer suppliers**

### 1-1. Criteria for evaluating first and second layer suppliers

According to the literature, so many criteria can be found in order to selecting the best supplier. This article has utilized some of common criteria which had been confirmed by famous researchers such as Weber [24]. The considered criteria are quality, financial status, delivery, manufacturing ability, service, record and previous layer. The definitions of criteria are as below:

Quality: refers to the quality of products delivered from first layer suppliers.

Financial status: refers to the financial capability of first layer suppliers such as its turnover or its profit during a financial year, etc.

Delivery: refers to delivery condition of first layer suppliers such as accuracy in delivery or packaging quality.

Manufacturing ability: refers to the ability of first layer supplier for manufacturing products such as manufacturing capacity or manufacturing flexibility, etc.

Service: refers to the guarantee of products offered by first layer suppliers.

Record: refers to the first layer supplier number of active years in industry and its reputation.

Previous layer: refers to the performance of suppliers in second layer conducted to first layer suppliers.

For evaluating second layer suppliers we considered the following criteria:

Quality: refers to the quality of raw materials delivered by second layer supplier.

Price: price of raw materials offered by second layer suppliers.

Green factors: represents how second layer supplier respect to environmental protection issues.

## 2. Proposed Method for Selecting the Best Supplier

The proposed method for selecting the best supplier is a combinatorial method comes from concepts in both Fuzzy Set Theory (FST) and Linear Programming (LP). It is also the development of the linear programming model introduced by Wan Lung NG [32].

According to the difficulties, decision makers incurred in pairwise comparison process with crisp data, we provide them some triangular fuzzy numbers (TFN) in order to simplify this process and gain more accurate comparisons among criteria and alternatives. We assume all criteria are positively related to the score of a supplier. The proposed method is as follows:

Step 1: Identify of linguistic terms and their triangular fuzzy numbers in order to simplify pairwise comparison process based on the criteria for both first and second layers of suppliers.

Step 2: Evaluate second layer suppliers against three aforementioned criteria by using linguistic terms and triangular fuzzy numbers.

$(\alpha_{lu}^{Q}, \beta_{lu}^{Q}, \gamma_{lu}^{Q})$ : Performance of $l^{th}$ supplier of $u^{th}$ raw material based on quality.

$(\alpha_{lu}^{P}, \beta_{lu}^{P}, \gamma_{lu}^{P})$ : Performance of $l^{th}$ supplier of $u^{th}$ raw material based on price.

$(\alpha_{lu}^{G}, \beta_{lu}^{G}, \gamma_{lu}^{G})$ : Performance of $l^{th}$ supplier of $u^{th}$ raw material based on green factors.

Step 3: Calculate the value of the criterion named as “previous layer” for first layer suppliers by aggregating the second layer supplier’s performance against quality, price, and green factors.

$n_i$: Number of raw materials required by $i^{th}$ supplier from the set of first layer suppliers.

$w_{iu}$: Importance of $u^{th}$ raw material for the $i^{th}$ supplier from the set of first layer suppliers $\sum_{u=1}^{n_i} w_{iu} = 1$ .

$(\lambda_i^{Q}, \theta_i^{Q}, \varphi_i^{Q})$ : Second layer suppliers aggregated performance for the $i^{th}$ supplier from the set of first layer suppliers against quality.

$(\lambda_i^{P}, \theta_i^{P}, \varphi_i^{P})$ : Second layer suppliers aggregated performance for the $i^{th}$ supplier from the set of first layer suppliers against price.

$(\lambda_i^{G}, \theta_i^{G}, \varphi_i^{G})$ : Second layer suppliers aggregated performance for the $i^{th}$ supplier from the set of first layer suppliers against green factors.

Based on Fig. 1 each supplier in the first layer is conducted to just one supplier in the second layer in order to obtain each raw material. So:

$$\lambda_i^{Q} = \sum_{u=1}^{n_i} w_{iu} \alpha_{iu}^{Q} \quad (1)$$

$$\theta_i^{Q} = \sum_{u=1}^{n_i} w_{iu} \beta_{iu}^{Q} \quad (2)$$

$$\varphi_i^{Q} = \sum_{u=1}^{n_i} w_{iu} \gamma_{iu}^{Q} \quad (3)$$

The 1st, 2nd and 3rd equations can be computed for price and green factors.

Step 4: Calculate final score of first layer suppliers according to the previous layer criterion.

$(\lambda_i, \theta_i, \varphi_i)$: Final score of $i^{th}$ supplier based on previous layer criterion.

$w^{Q}$ ، $w^{P}$ ، $w^{G}$: Importance of three criteria for set of first layer suppliers.

$$\lambda_i = w^{Q} \lambda_i^{Q} + w^{P} \lambda_i^{P} + w^{G} \lambda_i^{G} \quad (4)$$

$$\theta_i = w^{Q} \theta_i^{Q} + w^{P} \theta_i^{P} + w^{G} \theta_i^{G} \quad (5)$$

$$\varphi_i = w^{Q} \varphi_i^{Q} + w^{P} \varphi_i^{P} + w^{G} \varphi_i^{G} \quad (6)$$

Step 5: Compute first layer supplier performance against the aforementioned criteria by using the linguistic terms defined in step 1.

$(a_{ij}, b_{ij}, c_{ij})$ : Performance of the $i^{th}$ first layer supplier based on the $j^{th}$ criteria (except previous layer criterion).

$(\lambda_i, \theta_i, \varphi_i)$: Final score of $i^{th}$ supplier based on previous layer criterion.

Since some of the criteria might be possible to be exactly determined, then we may have some crisp data in our decision matrix, so we use triangular fuzzy numbers instead of crisp data such as *m* is equal to (*m*, *m*, *m*) (e.g. 2.0 = (2.0, 2.0, 2.0))

Then the basic decision matrix is constructed by using the performance of each supplier based on the criteria.

Since the physical dimensions and measurements of the criteria are different, so the fuzzy decision matrix needs to be normalized. In this paper, we choose the following normalization formula [34]:

$$(e_{ij}, f_{ij}, g_{ij}) = \left(\frac{a_{ij}}{\max_{i=1,2,\dots,I}(c_{ij})}, \frac{b_{ij}}{\max_{i=1,2,\dots,I}(b_{ij})}, \frac{\max_{i=1,2,\dots,I}(a_{ij})}{c_{ij}} \wedge 1\right) \quad (7)$$

Which $(e_{ij}, f_{ij}, g_{ij})$ is the final Performance of the $i^{th}$ first layer supplier based on the $j^{th}$ criteria.

Step 6: Identify criteria weights for each supplier which are arranged in the descending order of importance ( $w_{i1} \geq w_{i2} \geq \dots \geq w_{iJ}$ ) and $\sum_{j=1}^{J} w_{ij} = 1$.

Step 7: Construct the LP model.

$S_i, i = 1, 2, \dots, I$ : Score of the $i^{th}$ supplier of the set of first layer suppliers.

$$\begin{aligned} &Max \quad S_i = \sum_{j=1}^{J} w_{ij}(e_{ij}, f_{ij}, g_{ij}) \\ &s.t. \quad w_{ij} - w_{i(j+1)} \geq 0 \quad (j = 1, 2, \dots, J-1) \\ &\qquad \sum_{j=1}^{J} w_{ij} = 1 \\ &w_{ij} \geq 0 \quad (j = 1, 2, \dots, J) \end{aligned} \quad (8)$$

we adopt a transformation to simplify our model. The simplified model can be easily solved without a linear optimizer.

Note first:

$$u_{ij} = w_{ij} - w_{i(j+1)}, \quad \begin{matrix} i = 1, 2, \dots, I \\ j = 1, 2, \dots (J-1) \end{matrix} \quad (9)$$

and

$$u_{iJ} = w_{iJ} \quad (10)$$

Then

$$\sum_{j=1}^{J} j u_{ij} = 1 \quad (11)$$

$$u_{ij} \geq 0, \quad \begin{matrix} i = 1, 2, \dots, I \\ j = 1, 2, \dots, J \end{matrix} \quad (12)$$

Proof. See [32]

Note second:

$$h_{ij} = Difuzzify(e_{ik}, f_{ik}, g_{ik}) = \frac{e_{ij} + f_{ij} + g_{ij}}{3} \quad (13)$$

So:

$$S_i = \sum_{j=1}^{J} w_{ij}(e_{ij}, f_{ij}, g_{ij}) \Rightarrow \sum_{j=1}^{J} w_{ij} h_{ij} \quad (14)$$

Note third:

$$q_{ij} = \sum_{k=1}^{j} h_{ik}, \quad i = 1, 2, \dots, I \quad (15)$$

So by considering the equation 14 and 15, the objective function of the model would be transformed into below (16).

$$S_i = \sum_{j=1}^{J} w_{ij} y_{ij} = \sum_{j=1}^{J} u_{ij} q_{ij} \quad (16)$$

Proof. See [32]

By taking a glance on the transformations above, the LP model would appear as below:

$$\begin{aligned} &Max \quad S_i = \sum_{j=1}^{J} u_{ij} q_{ij} \\ &s.t. \quad \sum_{ij}^{J} j u_{ij} = 1 \\ &\qquad u_{ij} \geq 0, \quad j = 1, 2, \dots, J \end{aligned}$$

Then the optimal value of the model can be computed as (17):

$$Max_{j=1,2,\dots,J}\left(\frac{1}{j}\sum_{j=1}^{J} h_{ik}\right) \quad (17)$$

Proof. See [32]

Then the score of each supplier can be calculated as (18):

$$\frac{1}{j}\sum_{j=1}^{J} h_{ik} \quad (18)$$

## 3. Case study

The proposed supplier selection method has been applied in one of automotive related companies which has the mission of supplying parts for OEMs named as KAVEH KHODRO. Kaveh Khodro is in charge of supplying parts for Saipa Diesel which assemble parts in order to produce commercial cars. So in this article Kaveh Khodro is assumed as the main manufacturer. This company provide more than 1200 parts for Saipa Diesel and is conducted to too many suppliers in order to supply those parts. After a comprehensive review on part set in Kaveh Khodro, we found two products which approximately similar raw materials are required for manufacturing them, Brake Pads and Clutches. Afterwards we identified suppliers who are able to supply either one of the products or both of them. There were four called “Farazgaman Sanat“ , “Alaleh Soran“, “Jarfa Pajoh“, “Iran Sanat“ which middle two suppliers are able to supply both brake pads and clutches. By considering two aforementioned products they required at least eight raw materials which are shown in Fig 2. There are 2 suppliers for steel, Aluminum, Resin and graphite. Others just have one source of supply and they usually come from foreign countries. After identification the relations between first and second layers of suppliers, the proposed method can be implemented.

**Step 1:** the predefined linguistic terms and their triangular fuzzy numbers (Fig.3, Table. 1).

**Tab. 1. Triangular fuzzy numbers**

| Row | Linguistic Terms | Triangular Fuzzy Numbers |
|---|---|---|
| 1 | Very Low Performance | (0.1, 0.1, 0.3) |
| 2 | Low Performance | (0.2, 0.4, 0.6) |
| 3 | Medium Performance | (0.4, 0.6, 0.8) |
| 4 | High Performance | (0.6, 0.8, 1) |
| 5 | Very High Performance | (0.8, 1, 1) |

**Step 2:** Evaluation of second layer suppliers against quality, price and green factors (Table. 2).

Note: sine in our presented method, all criteria should be positive, so we use “inexpensiveness” instead of “price”.

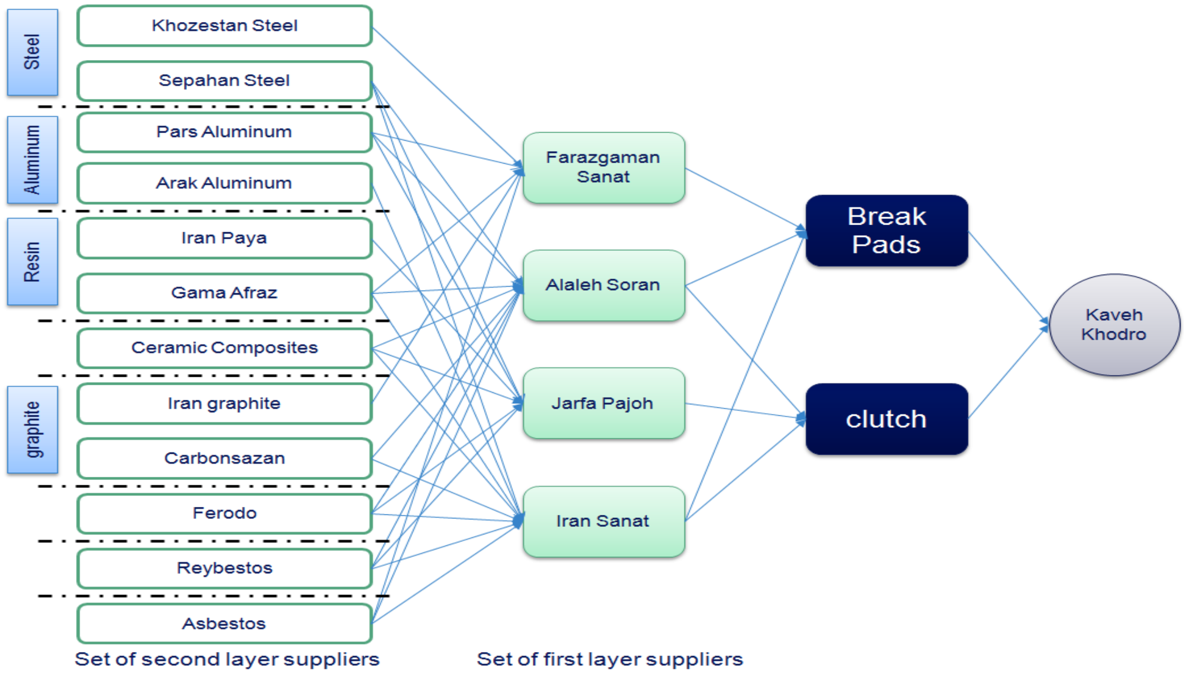


**Fig. 2. Selecting suppliers for brake pads and clutches in Kaveh Khodro**

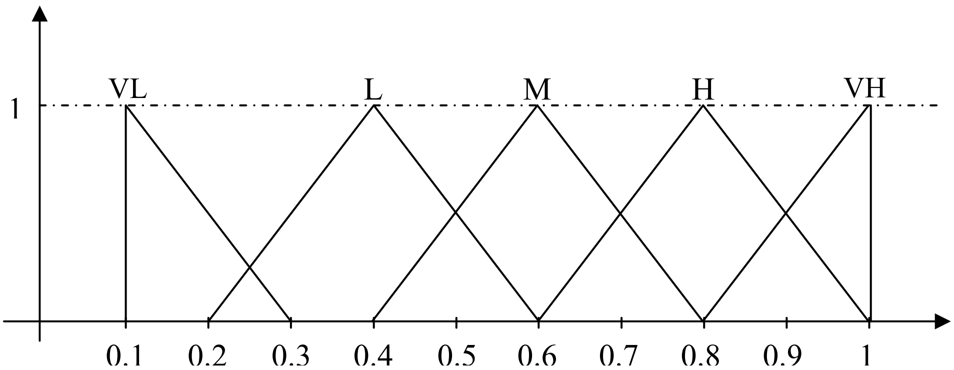


**Fig. 3. The predefined linguistic terms**

**Tab. 2. Performance scores of second layer suppliers against three criteria**

| Criteria \ Suppliers | Khozestan Steel | Sepahan Steel | Sundries | Iran Paya | Gama Afraz | Ceramic Composites | Iran graphite | Carbonsazan | Ferodo | Reybestos | Asbestos | Pars Aluminum | Arak Aluminum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quality | *H* | *VH* | *H* | *M* | *H* | *H* | *M* | *H* | *H* | *H* | *H* | *H* | *M* |
| Inexpensiveness | *M* | *L* | *M* | *M* | *L* | *L* | *M* | *L* | *M* | *VL* | *M* | *L* | *M* |
| Green factors | *M* | *M* | *L* | *M* | *L* | *M* | *H* | *M* | *M* | *H* | *VL* | *M* | *H* |

**Tab. 3.Final results for previous layer criteria**

| | Previous layer | | |
|---|---|---|---|
| | *L* | *M* | *U* |
| Farazgaman Sanat | 0.454444 | 0.647778 | 0.847778 |
| Alaleh Soran | 0.461574 | 0.651389 | 0.829167 |
| Jarfa Pajoh | 0.592063 | 0.601587 | 0.763492 |
| Iran Sanat | 0.449537 | 0.633796 | 0.806019 |

**Step 3 and 4:** Based on table 2 and by using equations 1 through 6, the final results for the "previous layer" criteria for each first layer supplier can be computed (Table. 3)

**Step 5:** Compute first layer suppliers performance against the aforementioned criteria by using the linguistic terms defined in step 1 (Table. 4) and the normalized values are in table (5).

**Step 6 and 7:** Calculation of LP model and gain the final score for each supplier in first layer (Table 6, Table 7, Table 8 and Table 9).

**Tab. 4. Performance scores for first layer suppliers based on predefined criteria.**

| | Quality | | | Financial Status | | | Delivery | | | Manufacture | | | Services | | | Record | | | Previous Layer | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Farazgaman Sanat | 0.4 | 0.6 | 0.8 | 0.6 | 0.8 | 1 | 0.6 | 0.8 | 1 | 0.4 | 0.6 | 0.8 | 0.6 | 0.8 | 1 | 6 | 6 | 6 | 0.454444 | 0.647778 | 0.847778 |
| Alaleh Soran | 0.6 | 0.8 | 1 | 0.4 | 0.6 | 0.8 | 0.6 | 0.8 | 1 | 0.4 | 0.6 | 0.8 | 0.6 | 0.8 | 1 | 5 | 5 | 5 | 0.461574 | 0.651389 | 0.829167 |
| Jarfa Pajoh | 0.6 | 0.8 | 1 | 0.6 | 0.8 | 1 | 0.2 | 0.4 | 0.6 | 0.4 | 0.6 | 0.8 | 0.4 | 0.6 | 0.8 | 2 | 2 | 2 | 0.592063 | 0.601587 | 0.763492 |
| Iran Sanat | 0.6 | 0.8 | 1 | 0.6 | 0.8 | 1 | 0.4 | 0.6 | 0.8 | 0.4 | 0.6 | 0.8 | 0.6 | 0.8 | 1 | 10 | 10 | 10 | 0.449537 | 0.633796 | 0.806019 |

**Tab. 5. Normalized scores for first layer suppliers**

| | Quality | | | Financial Status | | | Delivery | | | Manufacture | | | Services | | | Record | | | Previous Layer | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Farazgaman Sanat | 0.4 | 0.75 | 1 | 0.6 | 0.8 | 1 | 0.6 | 1 | 1 | 0.5 | 1 | 1 | 0.6 | 1 | 1 | 0.6 | 0.6 | 0.6 | 0.526042 | 0.994456 | 1 |
| Alaleh Soran | 0.6 | 1 | 1 | 0.4 | 0.6 | 1 | 0.6 | 1 | 1 | 0.5 | 1 | 1 | 0.6 | 1 | 1 | 0.5 | 0.5 | 0.5 | 0.556672 | 1 | 1 |
| Jarfa Pajoh | 0.6 | 1 | 1 | 0.8 | 1 | 1 | 0.25 | 0.66 | 1 | 0.5 | 1 | 1 | 0.4 | 0.75 | 1 | 0.2 | 0.2 | 0.4 | 0.724553 | 0.949181 | 1 |
| Iran Sanat | 0.6 | 1 | 1 | 0.6 | 1 | 1 | 0.5 | 1 | 1 | 0.5 | 1 | 1 | 0.6 | 1 | 1 | 1 | 1 | 1 | 0.557725 | 1 | 1 |

**Tab. 6. The difuzzified scores for suppliers in first layer**

| | Quality | Financial Status | Delivery | Manufacture | Services | Record | Previous Layer |
|---|---|---|---|---|---|---|---|
| Farazgaman Sanat | 0.71666666 | 0.8 | 0.86666666 | 0.83333333 | 0.86666666 | 0.6 | 0.84349941 |
| Alaleh Soran | 0.86666666 | 0.66666666 | 0.86666666 | 0.83333333 | 0.86666666 | 0.5 | 0.852224083 |
| Jarfa Pajoh | 0.86666666 | 0.93333333 | 0.63888888 | 0.83333333 | 0.71666666 | 0.2 | 0.894578018 |
| Iran Sanat | 0.86666666 | 0.86666666 | 0.83333333 | 0.83333333 | 0.86666666 | 1 | 0.852575145 |

**Tab. 7. Final scores of suppliers (a) - Normalized scores of suppliers (b)**

**(a)**

| | $S_i$ |
|---|---|
| Farazgaman Sanat | 5.460381 |
| Alaleh Soran | 5.607222 |
| Jarfa Pajoh | 5.619821 |
| Iran Sanat | 6.044177 |

**(b)**

| | $S_i$ |
|---|---|
| Farazgaman Sanat | 0.903412 |
| Alaleh Soran | 0.927706 |
| Jarfa Pajoh | 0.929791 |
| Iran Sanat | 1 |

**Tab. 8. Supplier ranking for brake pads (a) and clutches (b)**

**(a)**

| Break Pads | |
|---|---|
| | $S_i$ |
| Iran Sanat | 1 |
| Alaleh Soran | 0.927706 |
| Farazgaman Sanat | 0.903412 |

**(b)**

| Clutches | |
|---|---|
| | $S_i$ |
| Iran Sanat | 1 |
| Jarfa Pajoh | 0.929791 |
| Alaleh Soran | 0.927706 |

The results show that “Iran Sanat” won the competition and ranked as the best supplier among others. This means that Kavhe Khodro can use Iran Sanat as the only supplier for brake pads and clutches or it may utilize Iran Sanat for either brake pads or clutches and Jarfa Pajoh and Alaleh Soran for clutches and brake pads respectively.

## 4. Conclusion

In literature, there are so many supplier selection methods which include both MADM and MODM, but none of them did ever enunciated that a supply chain (SC) can have more than one layer of suppliers and the other layers can be very effective in total quality of SC and total cost incurred by supply chain. The presented article reveals a new approach of selecting suppliers by having a glance on suppliers who are placed in the previous layer of the first suppliers named as second layer suppliers. Then the proposed model has been applied in one of the automotive related companies which supplying parts for OEM’s is its mission. The model has been solved by one of the common MCDM methods, FANP. The results attained from the case shows that the new introduced procedure can make the supplier selection process more accurate and also it shows a new point of view which has been misled up to now.

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