A Scenario Oriented Supplier Selection by Considering a Multi Tier Supplier Network

Mohammad Najafi Nobar, Bahareh Pourmehr, and Mehdi Hajimirarab

***Abstract*—**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 model developed based on the features of second tiers suppliers and four scenarios are predicted in order to help the decision maker (DM) in making up his/her mind. In addition two tiers of suppliers have been considered as a chain of suppliers. 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 tier suppliers features as criteria for selecting the best supplier.

***Keywords*—**Supply Chain Management (SCM), Supplier Selection, Second Tier Supplier, Scenario Planning, Green Factor, Linear Programming, Fuzzy Set Theory

I. Introduction

Nowadays, competitive business environment has forced companies to satisfy customers who demand increasing product variety, lower costs, better quality and faster responses [1]. In each manufacturing process, the DM is faced to with lots of cost related parameters and if he wants to lower the cost, he should do a trade-off among them; therefore after the trade-off, the DM will be notified of those parameters that play a remarkable role in the increasing cost of production. One of the important cost parameters is cost of raw materials and component parts which comprise 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]. Most of the researches which announce (or *declare* or *proclaim*) supplier selection as an important process in supply chain management, consider that as a MCDM problem, containing both tangible and intangible factors.If this process is done correctly, a higher quality and longer lasting relationship is more attainable [5]. In other words, selection of wrong suppliers could be enough to endanger company's financial and operational position. Moreover, 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 De Boer, Labro and Morlacchi reviewed 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 survey 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 such as mathematical programming (MP), goal programming (GP), heuristic algorithms like genetic algorithm (GA) and so on, which all try to simplify the process, present higher accuracy and also seek some objectives such as 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 various applications in supplier selection process as many researchers utilized it and its derivatives like FAHP and ANP in their

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articles. As William mentioned in his article [18], AHP and ANP have been applied in ten articles out of 78 (about 13 percent) of international journal publications (or papers) which were reviewed. Partovi [26], Nydick [27] and Narasimahen [28] were named as early users of AHP in supplier selection. The main cause of applying AHP in such a process is its simplicity in calculation as well as its ability of handling both qualitative and quantitative factors.Furthermore, so many branches of 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 justify strategic alliances and partnering. Bottani [31] applied cluster analysis and AHP in order to simplify the purchase process and selecting the best supplier.Wan lung Ng [32] tried to select suppliers by utilizing linear programming along with transformation method and compared attained results with the outcomes obtained 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 technique in order to develop a model for supplier selection process in case of high quality and low prices. Kokangul [33] utilized AHP with non linear programming, and also multi objective programming to create a procedure for selecting suppliers with some parameters of interest such as higher capacity, discount offers, etc. While presenting different types of supplier selection methods, a few articles can be found which applied compensatory methods for supplier selection. In this article, a combinatorial method of linear programming and fuzzy set theory is applied for supplier selection. The rest of the paper is organized as follows:

The proposed Framework of supplier selection by considering features of second tier suppliers is introduced in section 2. Section 3 introduces the proposed combinatorial method of fuzzy set theory and linear programming. Application of aforementioned approach to a real problem and expressing a case study are in section 4. Finally, conclusion and references are discussed in section 5 and 6, respectively.

II. Proposed Framework of Selecting Suppliers by Considering 2nd Tier Suppliers Features

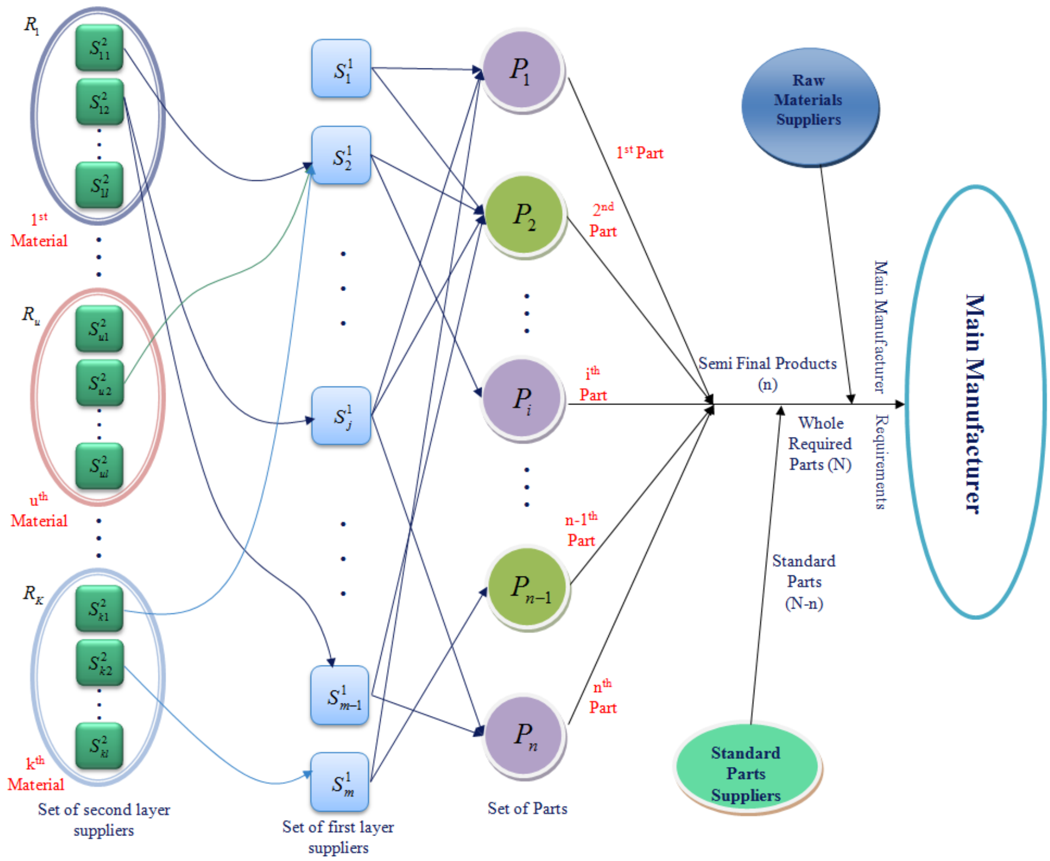
Firstly, it is considered that there exists an industrial unit with the aim of manufacturing products (such as cars, bicycles, etc) which are final products and ~~has~~ have the ability to be distributed directly to the market and be delivered to end users. Therefore, the main manufacturer requires a procedure in order to assemble some semi final products (SFP) and component~~s~~ parts by utilizing some raw materials and standard parts. So, the main manufacturer requirements could be divided into two categories; the first one includes raw materials and the second one contains standard parts and semi final products. Raw materials is referred to those substances which are directly used in assemble lines of the main manufacturer, and just have one tier of suppliers such as oil, glue, etc. the second category of suppliers are those who provide parts (in this article denoted as P). By assuming that the main manufacturer requires N parts, N can be separated into two groups. The first group embraces those ~~parts~~ materials/substances which are included in standard parts and manufactured in large amounts such as screws, nuts, etc. 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 $n \epsilon N$ be the number of substances in a second part. Let P_i demonstrate 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 may not need n suppliers and just in an exceptional situation the existence of n different suppliers will occur. Hence, suppliers in first tier can be formed into a set named "first tier suppliers" with m members (S_j^1 demonstrates the j^{th} supplier from m first tier suppliers).Considering the fact that manufacturing process in the place of first tier suppliers needs raw materials, hence each semi final products exploits some raw materials in order to be produced. Meanwhile, it's very common that some of the semi final products require similar raw materials, so 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 of n parts($g \subseteq n$), this supplier will require whole raw materials in order to produce g parts.Regarding to the concepts of first and second tier of suppliers, each supplier in first tier needs some raw materials based on what it can deliver. So S_{uj}^2 represents j^{th} second tier supplier for the u^{th} raw material (Fig. 1).

The proposed model contains four different sets which are as follows:

- Set of Parts (P): includes whole required semi final products (SFP) by main manufacturer.
- Set of first tier suppliers (S^1): includes the entire suppliers who are responsible of providing the SFP's for main manufacturer.
- Set of raw materials (R): includes whole required raw materials for manufacturing set of parts.
- Set of second tier suppliers (S^2): includes suppliers who are responsible of providing raw materials for first tier suppliers.

A. Criteria for evaluating first and second tier suppliers

According to the literature, so many criteria can be found in order to select the best suppliers. This article has utilized some of common criteria which had been confirmed by well-known researchers such as Weber [24]. The considered criteria are namely quality, financial status,



delivery, manufacturing ability, service, record and previous tier. The definitions of these criteria are as below:

- Quality: refers to the quality of products delivered from first tier suppliers.
- Financial status: refers to the financial capability of first tier suppliers such as its turnover or its profit during a financial year, etc.
- Delivery: refers to delivery condition of first tier suppliers such as accuracy in delivery or packaging quality.
- Manufacturing ability: refers to the ability of first tier supplier for manufacturing products such as manufacturing capacity or manufacturing flexibility, etc.
- Service: refers to the guarantee of products offered by first tier suppliers.
- Record: refers to the first tier supplier number of active years in industry and its reputation.
- Previous tier: refers to the performance of suppliers in second tier conducted to first tier suppliers.

For evaluating second tier suppliers we considered the following criteria:

- Quality: refers to the quality of raw materials delivered by second tier supplier.
- Price: price of raw materials offered by second tier suppliers.
- Green factors: represents how a second tier supplier respects environmental protection issues.

III. Scenario Planning

In order to better understanding of scenarios, we provide a hypothetical example for each scenario which contains one main manufacturer named A, four required manufacturing parts along with their production volume and ranking of suppliers for each part, and six suppliers (S1 ‹S2 ‹ S3 ‹S4 ‹S5 ‹ S6) who can provide the aforementioned parts. The rankings of the suppliers for each part are as follows:

$$Part1 \Rightarrow \quad S_3 < S_4 < S_1 \qquad Volume: 7000$$
$$Part2 \Rightarrow \quad S_4 < S_2 < S_1 < S_3 < S_5 \qquad Volume: 3000$$
$$Part3 \Rightarrow \quad S_4 < S_2 < S_6 < S_3 < S_1 \qquad Volume: 8000$$
$$Part4 \Rightarrow \quad S_5 < S_1 < S_6 \qquad Volume: 5000$$

As it can be seen, the first supplier is the one who can produce all of the required parts and the third part has the greatest production volume against the smallest production volume for second part. Therefore, four scenarios are designed as bellows:

1. *Centralized Scenario (CS)*

Centralized scenario focuses on supplying parts from the least number of suppliers; therefore, the main manufacturer will prefer to work with the one who can provide more than one parts.

Since the first supplier is the only supplier with the ability of providing company all of four parts, then it will be the only selected supplier for the main manufacturer. This scenario requires exact data in order to know the abilities of each supplier.

If this scenario be chosen the policy, then the risk of nourishing of production line with parts will increase, but order cost, flexibility on ordering and logistics cost will decrease. Hence this scenario will have effects on the bargaining ability of the main manufacturer.

2. *Decentralized Scenario (DS)*

This scenario focuses on providing each part from more than one supplier. Therefore, the main manufacturer will prefer the below decision:

$Part1 \Rightarrow S_1, S_4$

$Part2 \Rightarrow S_5, S_3$

$Part3 \Rightarrow S_1, S_3$

$Part4 \Rightarrow S_6, S_5$

If this scenario is selected, then the risk of nourishing of production line with parts will decrease, but in contrast with the previous scenario, the order cost, flexibility on ordering and logistics cost will increase. Hence this scenario will have effects on the bargaining ability of the main manufacturer and it will increase.

3. *Separated Scenario (SS)*

This scenario focuses on supplying parts from totally different suppliers and it prefers to supply them from various sources.

Therefore, the manufacturer must select its suppliers as follows. The considered scenario overlooks the production volume and having different providers is its only purpose.

$Part1 \Rightarrow S_1$

$Part2 \Rightarrow S_5$

$Part3 \Rightarrow S_3$

$Part4 \Rightarrow S_6$

If we choose this scenario, the risk of nourishing of production line with parts, order cost, flexibility on ordering and logistics cost will be in average. But this scenario provides a situation to grow some expert suppliers and also it helps the main manufacturer to play an important role in developing suppliers.

4. *Lexicographic Scenario (LS)*

This scenario is similar to separated scenario with the difference of considering the production volume as the condition of assigning suppliers which means it starts supplier's assignments from the one which has the greatest production volume (3rd) and moves to end. It also tries to have different suppliers for each part.

Based on the aforementioned scenario, the selected suppliers will be as follows.

$Part3(Volume: 8000) \Rightarrow S_1$

$Part1(Volume: 7000) \Rightarrow S_4$

$Part4(Volume: 5000) \Rightarrow S_6$

$Part2(Volume: 3000) \Rightarrow S_5$

Other features of this scenario are very similar to the separated scenario.

IV. 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 the decision makers incurred in pair wise 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 tiers of suppliers.

Step 2: Evaluate second tier 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 tier" for first tier suppliers by aggregating the second tier 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 tier suppliers.

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

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

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

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

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

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

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

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

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

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

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

w^Q ، w^P ، w^G: Importance of three criteria for set of first tier 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 tier supplier performance against the aforementioned criteria by using the linguistic terms defined in step 1.

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

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

The basic decision matrix is constructed 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 tier supplier based on the j^{th} criteria.

Step 6: Identify criteria weights for each supplier which are arranged in the descending order of importance ($w_{i1} \geq w_{i2} \geq \cdots \geq w_{iJ}$) 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 tier suppliers.

$$Max\ S_i = \sum_{j=1}^{J} w_{ij}(e_{ij}, f_{ij}, g_{ij})$$

$$\text{s.t.}\ \ w_{ij} - w_{i(j+1)} \geq 0 \quad (j = 1,2,\dots,J-1)$$

$$\sum_{j=1}^{J} w_{ij} = 1$$

$$w_{ij} \geq 0 \quad (j = 1,2,\dots,J) \quad (8)$$

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

Note first:

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

and

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

Then

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

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

Proof. See [32]

Note second:

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

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:

Max $S_i = \sum_{j=1}^{J} u_{ij}q_{ij}$

s.t. $\sum_{ij}^{J} j u_{ij} = 1$

$u_{ij} \geq 0,\ \ j = 1,2,\dots,J$

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

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

Proof. See [32]

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

$$\frac{1}{j}\sum_{j=1}^{J} h_{ik} \tag{18}$$

The proposed supplier selection method has been applied in one of automotive related companies (Kaveh Khodro) which has the mission of supplying parts for OEMs. Kaveh Khodro is in charge of supplying parts to 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 provides 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 with approximately similar raw materials needed to produce them. These two parts are 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 identifying the relations between first and second tiers of suppliers, the proposed method can be implemented.

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

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

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

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)

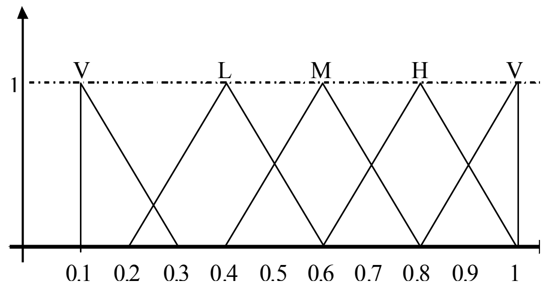


Fig. 3. The predefined linguistic terms

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

Step 5: Compute first tier suppliers performance against the aforementioned criteria by using the linguistic terms defined in step 1 (Table. 4). 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 tier (Table 6, Table 7, Table 8 and Table 9).

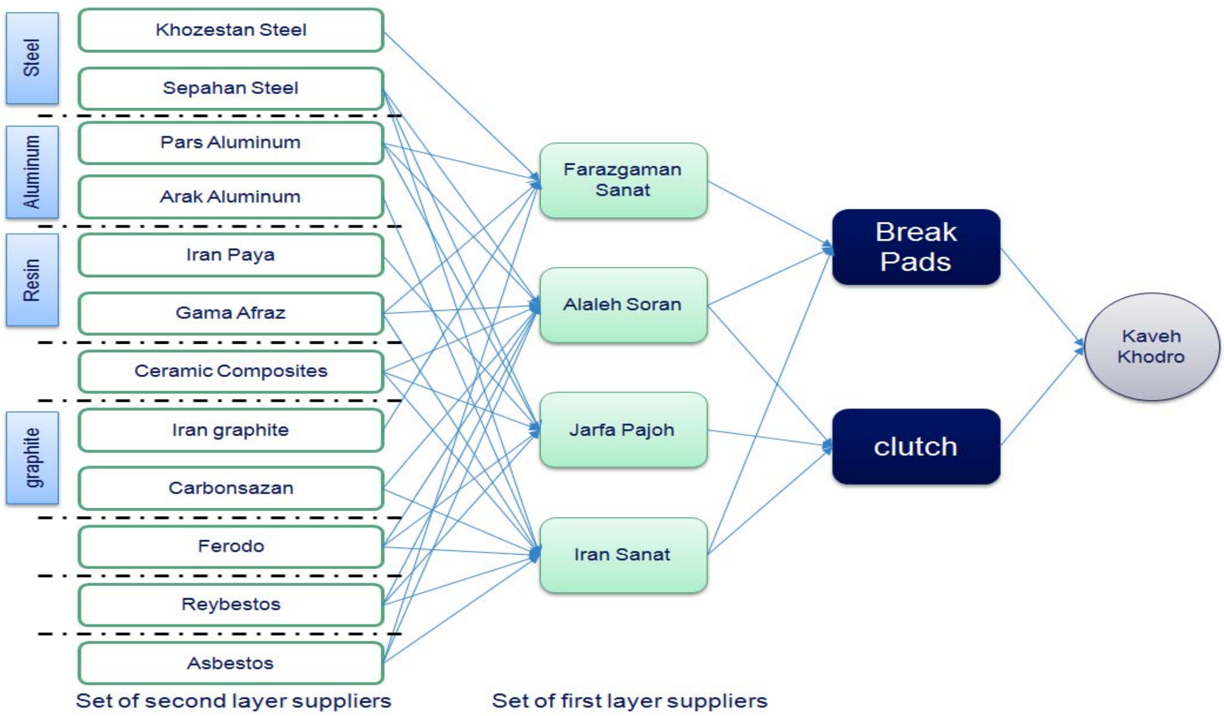


Fig. 1 The sequence of 1st and 2nd tier suppliers

TABLE II
PERFORMANCE SCORES OF SECOND TIER 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*

TABLE III
FINAL RESULTS FOR PREVIOUS TIER CRITERIA

	Previous tier		
	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

TABLE VI
THE DIFUZZIFIED SCORES FOR SUPPLIERS IN FIRST TIER

	Quality	Financial Status	Delivery	Manufacture	Services	Record	Previous Tier
Farazgaman Sanat	0.716	0.8	0.86	0.833	0.866	0.6	0.8434
Alaleh Soran	0.866	0.666	0.866	0.833	0.866	0.5	0.8522
Jarfa Pajoh	0.866	0.933	0.638	0.833	0.716	0.2	0.8945
Iran Sanat	0.86	0.866	0.833	0.833	0.866	1	0.8525

I. CONCLUSION

In literature, there exist so many articles which discuss supplier selection models and methods including MCDM and MADM, but none of them has ever emphasized the importance of considering multi tier suppliers in a supply chain (SC) which can play a significant role in quality improvement and cost reduction of the chain. In this article we presented a conceptual model with two tiers of suppliers which is extendable to three or more and also suggested an special scenario planning with four scenarios in order to simplifying the decision making process for the decision

TABLE IV
PERFORMANCE SCORES FOR FIRST TIER SUPPLIERS BASED ON PREDEFINED CRITERIA.

	Quality			Financial Status			Delivery			Manufacture			Services			Record			Previous Tier		
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

TABLE V
NORMALIZED SCORES FOR FIRST TIER SUPPLIERS

	Quality			Financial Status			Delivery			Manufacture			Services			Record			Previous Tier		
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

We utilized a linear programming as an MCDM tool in addition to fuzzy concepts with the aim of overcoming the vagueness nature of the problem. At the end we applied the aforementioned model in an automotive company with the mission of supplying parts for a manufacturing company and the results reveal that the proposed scenarios, as they are dependent on the company strategies and policies, have great impact on helping the decision maker to come up with a decision about selecting the best suppliers.

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