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Supplier Selection: A Fuzzy-ANP Approach

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Abstract

The main goal of this paper is to develop a framework to support the supplier selection process in an Iranian automotive industry. Although numerous criteria are being used for the selection of suitable supplier, selection of the critical factors in conformance to the specification of the automotive industries is less investigated. In order to fill this gap, this research was carried out to systematically propose a framework comprising of the most critical factors for the aim of supplier selection. A literature survey was conducted and measures for assessing the suppliers were extracted. Nominated Group Technique (NGT) was deployed to extract the most critical performance measures from the initial list. Seven measures were found to be proper for the supplier selection process. A Fuzzy Analytical Network Process (FANP) was then proposed to weight the extracted measures and determine their importance level. The model was then implemented to assist an automotive company for the aim of its supplier selection.

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Keywords: Supplier selection, Supplier evaluation, Fuzzy analytical network process.

1. Introduction

The aim of supply chain management and supplier selection is to fulfil customers' needs through all the chain suppliers. Selection of appropriate supplier can significantly lessen the purchase cost of the companies and consequently enhance the enterprise competitiveness [1]. Different criteria need to be considered for the supplier selection process. [2] declared that main focus of supplier selection were given to the price consideration. However single criterion policy in supplier selection was degraded the efficiency and performance of organization. In this regard an identification of 23 criteria has been done in a study by [2, 3]. Although numerous criteria were identified in the previous researches, the criteria for a specific industry might

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be different. This study is an attempt to provide a framework for supplier selection of an automotive industry. Providing an effective framework is important for the manufacturer due to several critical measures. Therefore, this research aimed to answer the following questions;

1. How to develop critical measures for supplier selection of an automotive industry?
2. How to weight the supplier selection measures considering their importance level?
3. How the qualitative factors can be involved in the process of supplier selection?

This research is an attempt to provide a simple and practical way to help managers evaluate potential suppliers. The proposed methodology is introducing a framework which evaluates supplier for semi-assembly parts of an Iranian automobile manufacturer. The framework uses variables and corresponding indexes for each criterion. In order to build the framework, the dominant criteria, and their respective indexes have to be identified.A seven step research methodology is considered for achieving the purpose of this research project. A case study of an automotive industry has been selected for this research and the most important criteria contributed to this area of research were identified. Finally a framework was developed for the ease of appropriate supplier selection. The rest of this paper is organized as follows. Section 2 is a review of recent works on supply chain management (SCM), and specifically on supplier selection and evaluation. Nominal Group Technique (NGT), Fuzzy Analytical network process (FANP) are presented in Section 3. After that our case study (Iranian automotive industry) will be proposed in section 4 also findings and implications will be discussed in this section as well. Some concluding remarks are provided in Section 5.

2. Literature Review

Supplier selection is the process of finding the suitable suppliers who can provide the buyer with the right quality products and/or services at the right price, in the right quantities and at the right time [3-5]. Existing researches in the field of supplier selection can be divided into two major categories: those focusing on isolating different supply source selection criteria and assessing the degree of their importance from the purchasing firm's point of view and second those aiming to identify different alternative suppliers by developing and applying specific methods [6]. In order to select the appropriate supplier recent problem-solving method should be utilized. These problem solving method contribute to the problem definition, formulation of criteria, qualification, and finally choice of suitable supplier[7]. Evaluation process of appropriate supplier consists of several conflicting criteria which the MCDM method is implemented to manage this problem.

Supplier selection can be done using different supply chain strategies [8]. There are many frameworks for the aim of assessing suppliers' performance [9]. These frameworks have different measures which lead in different scenarios [10]. Supplier selection measures may be both quantitative and qualitative. This can justify the need of integrating both qualitative and quantitative measures in a unique framework. In addition, companies' desires are not the same regarding all criteria. They may increase the weight of one measure and decrease the other one. Multi-criteria decision making approaches (e.g. AHP, ANP and etc.) seem to be a proper tool for the aim of weighting these criteria. Finally, considering all these issues can be a good contribution toward supplier selection. This study aims to provide a supplier selection framework for automotive industries. This framework considers the most critical factors considering the characteristics of automotive industries. The capability of this framework to assign different weights to supplier selection criteria aligned with its generality to be used in similar case will make a significant contribution toward this area which has been investigated less in the available literature.

3. Methodology

The initial step is to identify, through the Nominal Group Technique (NGT), the essential criteria for which the examination of applicability is crucial in the supplier selection process for making an objective and unbiased decision. Then, the degree of interdependent relationships between different criteria is determined by the expert group via NGT, and the interdependence will affect the final weights of criteria. Afterwards, each decision maker or expert elicits an appropriate weight for each criterion using the ANP. According to information and experts' idea criteria were chosen and by using NGT method researcher want to take everyone's opinions into account. Then, with this method (NGT) identities the interdependence among the criteria were pointed out and eventually the weight of criteria was calculated by using FANP method. According to the criteria comprehensive checklist was designed and supplier was audited. Finally, according to the score obtained, the supplier is accepted or rejected.

3.1. Identification of Criteria

The first step is to identify the necessary criteria for which the examination of applicability is vital in the supplier selection process for making an objective and unbiased decision. In this case, the researcher first conducts a desk research, and then by reviewing the articles and the researchers conducted regarding this issue, the criteria will be refined. Those criteria that appear most often in these documents will be selected. Next, the researcher investigates instructions and procedures, previous suppliers' records, to find criteria which are important to consider, in order to selecting suppliers. Finally, according to experts and professionals' points of view, the researcher uses Nominal Group Technic (NGT) which is one of the formal group management techniques for determining a set of evaluation criteria. This process forces everyone to participate and no dominant person is allowed to come out and control the proceedings. In NGT, all ideas have equal stature and will be judged impartially by the group [7].

3.2. Recognition of the Interdependence between Criteria

To simplify the process and avoid any misunderstandings, the interaction between any two of these criteria is not considered in the fist instance. Then, the repercussion of interdependent relationship between different criteria must be known in order to find the exact link between criteria in analytical network process (ANP). To achieve this, the researcher uses NGT for determining interdependence between criteria by the expert group, and the interdependence will affect the final weights of criteria.

3.3. Determination of the Weights of Criteria

Afterwards, each expert elicits an appropriate weight for each criterion using the FANP method. To determine the relationship of the degree of interdependence, the ANP technique, which is an extension of AHP, is used to address the relative importance of the criteria. ANP is developed to generate priorities for decisions without making assumptions about an unidirectional hierarchy relationship between decision levels [11, 12]. The relative importance or strength of the impacts on a given element is measured on a ratio scale, which is similar to AHP. Reference [11] explains the concept corresponding to the Markov chain process. Here, the matrix manipulation relies on the concept of Saaty and Takizawa (1986) [13] instead of Saaty's original supermatrix for ease of understanding. Also Saati proves that the final weight of the criteria is measured by using the probability matrices and the Markof chains using the following formula:

$$w = \lim_{k \to \infty} w^{2k+1} \quad (1)$$

In this research, to make it simpler, instead of the initial idea of supermatrix, which has been presented by Saaty, the matrix calculations are based on [13]. Because of the characteristics of supplier selection, we explore the appropriateness of ANP allowing the explicit consideration of interactions in the process [14]. The remaining work will be described as follows. Without assuming the interdependence between criteria, the experts are asked to evaluate all proposed criteria pair-wise. They responded to questions such as: “Which criteria should be emphasized more in a supplier, and how much more?”
Although the experts utilize their high intellectual capabilities to do the comparisons, but we should consider the point that AHP lacks the ability to reflect the way the human thinks. In other words, using fuzzy sets will be more compatible with linguistic terms and ambiguities related to human beings. Thus, it’s better to use fuzzy numbers in order to do long-term predictions and make decisions in the real world situation. [12] contended that the geometric mean accurately represents the consensus of experts and is the most widely used in practical applications. Here, geometric mean is used as the model for triangular fuzzy numbers. Since each number in the pair-wise comparison matrix represents the subjective opinion of decision makers and is an ambiguous concept, fuzzy numbers work best to consolidate fragmented expert opinions.

$$M_{ij} = \left(l_{ij}, m_{ij}, u_{ij}\right) \tag{2}$$

$$l_{ij} = \min\left(B_{ijk}\right) \tag{3}$$

$$m_{ij} = \sqrt[n]{\prod_{k=1}^{n} B_{ijk}} \tag{4}$$

$$u_{ij} = max\left(B_{ijk}\right) \tag{5}$$

Where B_{ijk} represents a judgment of expert k for the relative importance of two criteria $C_i - C_j$. The algebraic operations of any two triangular fuzzy numbers $M_1$and M_2 can be expressed as;

$$M_1 + M_2 = \left(l_1 + l_2, m_1 + m_2, u_1 + u_2\right) \tag{6}$$

$$M_1 * M_2 = \left(l_1 * l_2, m_1 * m_2, u_1 * u_2\right) \tag{7}$$

$$M_1^{-1} = \left(\frac{1}{u_1}, \frac{1}{m_1}, \frac{1}{l_1}\right), M_2^{-1} = \left(\frac{1}{u_2}, \frac{1}{m_2}, \frac{1}{l_2}\right) \tag{8}$$

Note that the multiplication of two triangular fuzzy numbers or the convex triangular-fuzzy number is no more a triangular fuzzy number. Such equations just represent an approximation of real multiplication of two triangular fuzzy numbers and the convex of one triangular fuzzy number. In EA method, for each column of pairwise matrix, S_k which is a triangular number itself, the following equation is used. The fuzzy combined value for the i^{th} entity is defined as:

$$S_k = \sum_{j=1}^{n} M_{kj} * \left[\sum_{i=1}^{m}\sum_{j=1}^{n} M_{ij}\right]^{-1} \tag{9}$$

In EA method, after calculating S_k, their degree of possibility to each other should be determined. In all, if M_1 and M_2 are two triangular fuzzy numbers, the degree of possibility M_1 over M_2 which is shown this way ($M_1 >= M_2$), is defined as follows:

$$\begin{cases} V(M_1 \geq M_2) = 1 & \text{if } M_1 \geq M_2 \\ V(M_1 \geq M_2) = 0 & \text{if } L_1 \geq U_2 \\ V(M_1 \geq M_2) = hgt(M_1 \cap M_2) & \text{otherwise} \end{cases} \quad (10)$$

$$hgt(M1 \cap M2) = \frac{u_1 - l_2}{(u_1 - l_2) + (m_2 - m_1)} \quad (11)$$

Baas-Kwakernaak method was criticized by Baldwin and Guild for the lack to the discriminatory power resulting in inappropriate choices, and by Dubois and Prade for not including all the available information present in membership functions [15-17]. Also, we have magnificence scale of a triangular number from other k number of the triangular number comes out from the equation (9):

$$V(M_1 \geq M_2 \ldots M_k) = V(M_1 \geq M_2), \ldots, V(M_1 \geq M_k) \quad (12)$$

To calculate the weights of indices in pairwise matrix, the following steps are taken:

$$W(x_i) = Min\{V(S_i \geq S_k)\} \quad k = 1, 2, 3, \ldots, n \;\; k \neq i \quad (13)$$

Thus, the weight vectors are defined as mentioned below:

$$w'(X_i) = [W(C_1), W(C_2), W(C_n)]^T \quad (14)$$

Which is the same non-normal coefficient of the fuzzy AHP. By using the equation (12), the non-normal results gained from the equation (11) will change to normal. The changed-to-normal results are called W.

$$W_i = \frac{W_i'}{\sum w_i'} \quad (15)$$

Next, the effects of correlations between criteria are determined. The group members measure the effects of all criteria against each other by pairwise comparisons. To make the comparison process simple, a set of questions like, “which criteria affects more on C3 criteria? C2 or C1 and how much more?” are answered. For each criterion, matrices made by pairwise comparisons are created. Such pairwise comparison matrices are required to identify the relative impacts of criteria interdependent relationships. The main specific normal vectors of these matrices are shown in column elements in matrix B regarding weights correlations. In this matrix the 0s for the weights of specific vectors are considered as criteria that have no correlation with each other. Now we can calculate the comparative correlation of the criteria by using equation (16), or in other words by combining the two previous steps. Here by combination we mean execution of coefficient interdependence weight matrix over the results of the fuzzy AHP process. The combination of these two has the same meaning as fuzzy network analysis.

$$W_c = B.W \quad (16)$$

3.4. Creating a Check-list According to the Criteria

The audit checklist and framework of the application are defined according to the criteria. For Instance, indexes are defined for each criterion and are given appropriate marks to compute the value of each criterion.

3.5. Gather the Criteria Values by Auditing

The audit is an independent assessing method with a view to determining whether the supplier for each criterion meets the reliable provisions with respect to the checklist, and whether these provisions are implemented effectively and are capable of ensuring supplier conformance with the criteria. The audit reference system to be complied with and the rating schedule for the assessment of the supplier. Schedule and rating criteria are based on the following principles. Rating schedule demerit by criterion (value from 0 to 3) based on the most unfavorable score observed during examination of the criterion. The rating values are described in Table 1.

Table 1: Criterion rating values

Criterion Rating	Level of conformance	Observation
3	Satisfactory	The criterion audited is taken into account; the auditor detects no deviation relative to the reference file.
2	Acceptable	The criterion is taken into account; the auditor detects small deviations relative to the reference file.
1	Inadequate	The criterion audited is taken into account; the auditor detects major deviations relative to the reference file.
0	Unsatisfactory	The criterion or a part of the criterion is not taken into account.

3.6. Computing the Total Score of Supplier

The overall rating for each criterion provides a synopsis of the process items audited. The conformance criterion is based on the total number of index for each criterion taken into account. Its value (as a percentage) is calculated as follows:

$$\text{Conformance criterion} = \frac{\text{sum of index result rate for each criterion}}{\text{sum of index rate for each criterion}} \tag{17}$$

$$\text{Total score} = \text{value of conformance criterion} * \text{related weight} \tag{18}$$

3.7. Rating the Total Score for Selecting the Reliable Supplier

Based on to the total score, supplier categorized into one of three possible situations. It is shown in Table 2.

Table 2: Decision making guideline

Rating	Result	Observations
T.S ≥80% and score of criteria was more than 50%	Acceptable Level A	The supplier is eligible to select.
70% ≤T.S < 80% and score of criteria was more than 50%	Under supervision Level B	The supplier is not good but can be selected in order to make the primary contract. The supplier has to evolve to status "80% ≤T.S" within a period of 12 months maximum.
T.S < 70% or one score of criteria was less than 50%	Not acceptable Level C	The supplier reject from the panel.

Where TS = total score.

4. Result and Discussion

Seven criteria were chosen as the main measures for the aim of evaluating suppliers.C1 = Quality, C2= Price, C3 = Production capacity, C4 = Technical capability& Facility, C5 = Service & Delivery, C6 = Reputation, C7 = Geographical location. Identification of the interdependence between criteria is necessary to be performed. In order to correctly show the interdependence between the criteria, we need to find out the exact relationship in a network structure of ANP. We use NGT process to come out with the relationships based on the following assumption;

I. Price may be influenced by the quality of products and geographical location.
II. Quality may be affected by technical capability and facility and service and delivery.
III. Production capacity may be influenced by technical capability and facility.
IV. Reputation is affected by technical capability and facility and quality.
V. Service and delivery may be affected by geographical location and production capacity.

Figure 1 represents the relationship of interdependency. For instance, the arrow that leaves from C4 and feeds into C3 shows that the relationship of criterion C4 has an influence on criterion C3.

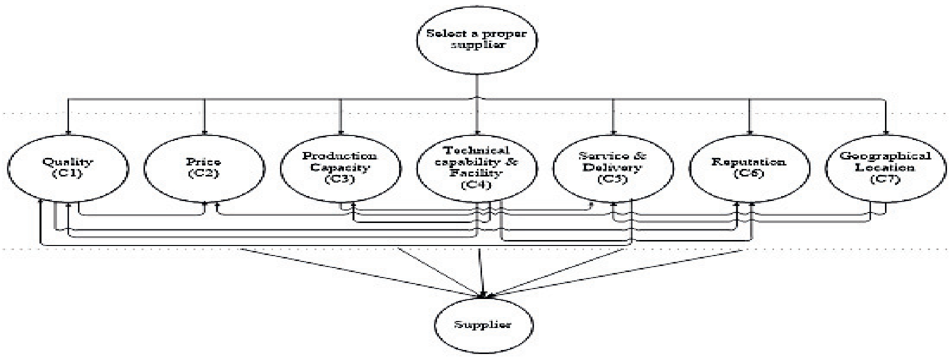

Fig 1: The interdependent relationship between selected criteria

The next step is to compute the weight of each criterion. In this project, a team of four experts in the case study was selected. They were asked to evaluate all criteria base on pairwise method despite the assumption on the interdependence between them. The final pairwise comparison matrix is shown in Table 3.

Table 3: The combination matrix of four expert ideas

	C1	C2	C3	C4	C5	C6	C7
C1	(1,1,1)	(0.33,0.51,1)	(0.5,1.39,3)	(0.5,1.46,2.5)	(1,1.46,2.5)	(1,2.18,3.5)	(2,2.5,3)
C2	(1,1.97,3)	(1,1,1)	(1,2.08,3)	(1,1.83,3)	(0.5,1.46,2.5)	(0.5,1.92,3.5)	(1.5,2.24,3)
C3	(0.33,0.72,2)	(0.33,0.48,1)	(1,1,1)	(0.4,0.84,2)	(0.33,0.67,2)	(0.33,1.32,3)	(0.5,1.19,2.5)
C4	(0.4,0.69,2)	(0.33,0.55,1)	(0.5,1.19,2.5)	(1,1,1)	(0.5,1.36,2)	(1,1.86,2.5)	(1,2.08,3)
C5	(0.4,0.69,1)	(0.4,0.69,2)	(0.5,1.50,3)	(0.5,0.74,2)	(1,1,1)	(1,2.06,3.5)	(0.5,1.65,3)
C6	(0.29,0.46,1)	(0.29,0.52,2)	(0.33,0.76,3)	(0.4,0.54,1)	(0.29,0.49,1)	(1,1,1)	(0.5,1.46,2.5)
C7	(0.33,0.4,0.5)	(0.33,0.45,0.67)	(0.4,0.84,2)	(0.33,0.48,1)	(0.33,0.60,2)	(0.4,0.69,2)	(1,1,1)

Example calculation for M_{42};

$$M42 = \left(L_{42}, m_{42}, u_{42}\right) = \left(0.33, 0.55, 1\right)$$

$$L_{42} = \min\left(B_{42k}\right) = \min\left(0.40, 0.33, 0.50, 0.50\right) = 0.33$$

$$m_{42} = \sqrt[4]{\prod_{k=1}^{4} B_{42k}} = \sqrt[4]{0.5*0.4*0.67*0.67} = 0.55$$

$$u_{42} = \max\left(B_{42k}\right) = \max\left(0.67, 0.5, 1.1\right) = 1$$

To calculate S_k, values of all calculation was done with Excel spreadsheets and the following results are obtained;

S_1 = (6.33, 10.49, 16.50) * (0.010, 0.018, 0.032) = (0.064, 0.188, 0.527)
S_2 = (6.50, 12.49, 19.00) * (0.010, 0.018, 0.032 = (0.066, 0.223, 0.607)
S_3 = (3.23, 6.21, 13.50) * (0.010, 0.018, 0.032) = (0.033, 0.111, 0.431)
S_4 = (4.73, 8.72, 14.00) * (0.010, 0.018, 0.032) = (0.048, 0.156, 0.447)
S_5 = (4.30, 8.32, 15.50) * (0.010, 0.018, 0.032) = (0.043, 0.149, 0.495)
S_6 = (3.09, 5.22, 11.50) * (0.010, 0.018, 0.032) = (0.031, 0.093, 0.367)
S_7 = (3.13, 4.46, 9.17)* (0.010, 0.018, 0.032) = (0.032, 0.080, 0.293)

Example of calculation for S_1;

$$S_1 = \sum_{j=1}^{7} M_{1j} * \left[\sum_{i=1}^{7}\sum_{j=1}^{7} Mij\right]^{-1}$$ = (1+0.3+0.5+0.5+1+1+2, 1+0.51+1.39+1.46+1.46+2.18+2.5, 1+1+3+2.5+2.5+3.5+3)
*(6.33+6.5+3.23+4.73+4.3+3.09+3.13,10.49+12.49+6.21+8.72+8.32+5.22+4.46,16.5+19+13.5+14+15.5+11.5+9.17)-1
=(6.3, 10.49, 16.5) * (31.32, 55.91, 99.17) -1 = (6.4, 10.49, 16.5) * (0.01, 0.018, 0.032) = (0.064, 0.188 ,0.527)

The degree of possibility (V ($S_i \geq S_j$)) among these seven fuzzy synthetic extent value (S_1 to S_7) can be obtained. The computational process is shown in Table 4.

Table 4: The degree of possibility of each member against other members.

S1≥S2 = 0.92	S2≥S1= 1	S3≥S1=0.82	S4≥S1 = 0.92	S5≥S1 = 0.91	S6≥S1 = 0.76
S1≥S3 = 1	S2≥S3 = 1	S3≥S2 = 0.76	S4≥S2 = 0.84	S5≥S2 = 0.85	S6≥S2 = 0.69
S1≥S4 = 1	S2≥S4 = 1	S3≥S4 = 0.89	S4≥S3 = 1	S5≥S3 = 1	S6≥S3 = 0.94
S1≥S5 = 1	S2≥S5 = 1	S3≥S5 = 0.91	S4≥S5 = 1	S5≥S4 = 0.98	S6≥S4 = 0.83
S1≥S6 = 1	S2≥S6 = 1	S3≥S6 = 1	S4≥S6 = 1	S5≥S6 = 1	S6≥S5 = 0.85
S1≥S7 = 1	S2≥S7 = 1	S3≥S7 = 1	S4≥S7 =1	S5≥S7 = 1	S6≥S7 = 1

Using the equations of (12) to (15), the weight vector and normalized weight vector of each criterion can be obtained. The calculations are as follows:

Min V(S1≥S2,S3,S4,S5,S6,S7) = Min(0.93,1,1,1,1,1) = 0.93
Min V(S2≥S1,S3,S4,S5,S6,S7) = Min(1,1,1,1,1,1) = 1
Min V(S3≥S1,S2,S4,S5,S6,S7) = Min(0.83,0.76,0.89,0.91,1,1) = 0.76
Min V(S4≥S1,S2,S3,S5,S6,S7) = Min(0.92,0.85,1,1,1,1) = 0.85
Min V(S5≥S1,S2,S3,S4,S6,S7) = Min(0.92,0.85,1,0.98,1,1) = 0.85
Min V(S6≥S1,S2,S3,S4,S5,S7) = Min(0.76,0.69,0.95,0.84,0.85,1) = 0.69
Min V(S7≥S1,S2,S3,S4,S5,S6) = Min(0.68,0.61,0.89,0.76,0.78,0.95) = 0.61

The weight vector of the criteria is calculated as:

W' = (0.9281, 1, 0.7650, 0.8498, 0.8520, 0.6988, 0.6126)T

And the normalized weight vector is:

W = (0.1626, 0.1752, 0.1341, 0.1489, 0.1493, 0.1225, 0.1074)

Finally, the interdependence between the criteria is now considered. All the experts examine the impact of all the criteria by pairwise comparison. Researcher used geometric mean, by using an equation $a_{ij} = \sqrt[n]{\prod_{k=1}^{n} a_{ijk}}$ to combine pairwise comparison matrixes. All calculation was done with Excel spreadsheets as shown in Appendix D; the final pairwise comparison matrix is shown in Table 5:

Table 5: The final aggregate matrix.

Combination of four expert ideas	C1	C2	C3	C4	C5	C6	C7
C1	1	1.5	0	0	0	2.36	0
C2	0	1	0	0	0	0	0
C3	0	0	1	0	2.23	0	0
C4	2.36	0	2.11	1	0	1.5	0
C5	1.5	0	0	0	1	0	0
C6	0	0	0	0	0	1	0
C7	0	1.86	0	0	2.23	0	1

The normalized eigenvector for these matrices is calculated. First sum the values in each column of the pairwise comparison matrix. Next, we divide each value in a column by its corresponding column sum. Zeros value shows the eigenvector weights of the criteria with no interdependent relationship. These results in a normalized matrix as shown in Table 6.

Table 6: Normalized decision matrix.

Criteria	C1	C2	C3	C4	C5	C6	C7
C1	0.21	0.34	0	0	0	0.49	0
C2	0	0.23	0	0	0	0	0
C3	0	0	0.32	0	0.41	0	0
C4	0.49	0	0.68	1	0	0.31	0
C5	0.31	0	0	0	0.18	0	0
C6	0	0	0	0	0	0.21	0
C7	0	0.43	0	0	0.41	0	1

The weight of the criteria can be obtained using equation (16);

$$w_c = \begin{bmatrix} 0.1626 \\ 0.1752 \\ 0.1341 \\ 0.1489 \\ 0.1493 \\ 0.1225 \\ 0.1079 \end{bmatrix} * \begin{bmatrix} 0.2056 & 0.3439 & 0 & 0 & 0 & 0.4861 & 0 \\ 0 & 0.2293 & 0 & 0 & 0 & 0 & 0 \\ 0 & & 0.3211 & 0 & 0.4086 & 0 & 0 \\ 0.4861 & 0 & 0.6789 & 1 & 0 & 0.3084 & 0 \\ 0.3084 & 0 & 0 & 0 & 0.1827 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0.2056 & 0 \\ 0 & 0.4268 & 0 & 0 & 0.4086 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 0.1532 \\ 0.0402 \\ 0.1041 \\ 0.3568 \\ 0.0774 \\ 0.0252 \\ 0.2437 \end{bmatrix}$$

Also the sequence of the criteria according to the priority is shown in Figure 2.

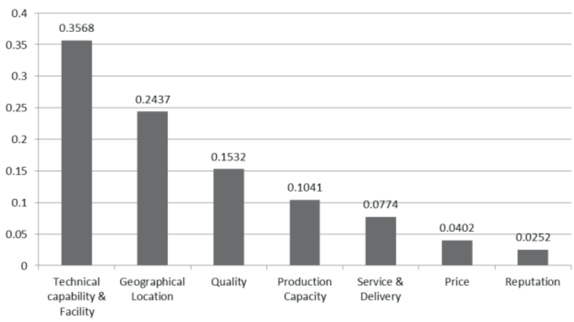

Fig 2: Priorities of the criteria.

4.1. Creating a Check-list According to Criteria

Evaluation checklist is a tool designed to audit supplier. The evaluation is based on 66 questions, divided into seven criteria (named chapter). At the end of each chapter auditor will find boxes in which auditor will explain his/her choices and express his/her opinions about a specific. The total score is calculated according to equations (17) and (18). All calculation was done with Excel spreadsheets. Selected good supplier is evaluated based on the score for each criterion and this should not be less than 50% and total score should not be less than 80%. If the total score is between 70% and 80% and the score for each criterion is not less than 50%, the supplier can be accepted with further supervision. The supplier has to evolve to status “80%≤ T.S” within a maximum period of 12 months. If the T.S < 70% or one score of criteria is less than 50% the supplier will be rejected from the assessment.

5. Conclusion

The study concentrated on supplier selection problems. This paper aimed to attain the collection of criteria which have impacts on selecting a reliable supplier. As a result, NGT method was used to summarize the most critical factors. A fuzzy analysis network process (FANP) method was deployed to weight the selected criteria. Finally, in order to select a reliable supplier the evaluation process need to be performed using related checklists. The checklist can be found in the appendix.

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