# Application of Analytic Hierarchy Process Method and VIKOR for ABS Market of Countrie

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## 1. Introduction

In recent years, the export of petrochemical products has accounted for the largest share of the country's non-oil exports in the international region, and according to the 1404 country vision document, in the petrochemical industry of Iran should also be a former supporter of Saudi Arabia. Rubber/ABS polymer Anti-Jam project is one of the second phase projects of Jam petrochemical in Pars Energy special economic Zone, located in Assaluye port. In the above project, it is predicted to produce two strategic and high-consumption products, which include: 1-Acrylonitrile Butadiene Styrene (ABS) with a capacity of 200000 tons per year. 2-Rubber (SB/LCBR rubber) with a capacity of 60000 tons per year. In this project, we consider the global market studies of ABS production.

ABS production methods

| Limitations | Advantages | production |
|---|---|---|
| High fixed capital, High Energy consumption | Variety in the product | Emulsion |
| Limitation on product diversity | Less investment | Mass |
| Not used commercially | | Suspension |

Early research into ABS were developed in 1930 for aircraft and conducted by Bosch after that Teldix Gm BH, constricted first generation of ABS systems that stopped wheels without lock up. ABS is applicable approximately to all kinds of vehicle and can be successfully integrated into air and hydraulic brave systems. In former systems, ABS consist of a hydraulic modulator (control valve), control electronics (central unit), and sensors mounted on wheels. Kutlu Gündoğdu and Kahraman (2019) have recently introduced the spherical fuzzy sets (SFS). Analytical Hierarchy Process (AHP) is a mathematical tool of problem solving that has become popular amongst management personnel in the late 1990's and early 2000's. The AHP method has been created after understanding the structure of a problem and the real hindrance that managers face while solving it. Moreover, since decision making generally requires multiple perspectives from different people, most organizational decisions are made in groups (Ma, Lu&Zhang,2010). MCDM is used to select the most desirable alternative(s) from a set of available alternatives based on the selection criteria defined (Ju & Wang,2013). The classical MCDM frameworks assume that the ratings and the weights of the criteria are known precisely. However, many real-world problems involve uncertain data and one cannot assume the knowledge and judgments of the decision makers (DMs) or experts to be precise (Sayadi, Heydari, & Shahanaghi, 2009). The VIKOR method is suitable for those situations where the goal is to maximize profit while the risk of the decisions is deemed to be less important. The major advantage of the VIKOR method is that it can trade off the maximum group utility of the ''majority'' and the minimum individual regret of the ''opponent''. In addition, the required calculations are simple and straightforward (Bazzazi, Osanloo, & Karimi, 2011). The VIKOR method was introduced by Opricovic in 1998 to model the multi-criteria optimization of complex systems (Opricovic, 1998). This method focuses on ranking and selecting from a set of available alternatives in the presence of conflicting criteria by proposing a compromise solution (composed by either one or several alternatives) (Opricovic & Tzeng, 2007). The MCDMs have various techniques in different decision-making stages. In these methods, based on mathematical reasoning, several alternatives are compared based on several different criteria; the best alternative or arrangement of the appropriate alternatives is chosen (Dağdevrıenö M, yüksel). The VIKOR method is developed by Opricovic and Tzeng (2004) to solve MCDM problems with conflicting and uncertain criteria (Yücenur & Demire 2012). Kaya and Kahraman (2010) proposed a methodology based on an integrated fuzzy AHP-VIKOR method to determine the best renewable energy alternative for Istanbul (karakas 2019). San Cristóbal, worked on a renewable energy project in Spain. AHP produced the weights of the criteria which are then used to yield a consistency ranking by the VIKOR method. Moreno-Jiménez et al (San Cristóbal, 2011).

**Method and Methodology**

❑   Analytical Hierarchy Process

In the AHP method that we use to calculate the weights of the criteria, the pairwise comparison matrix of criteria is determined by using the Saaty (1–9) preference scale as shown in Table 1. Then the consistencies of calculated weights are analyzed by interpreting the consistency index and consistency ratio.

Table 1. Saaty (1–9) Preference Scale.

| Scale | Definition | Explanation |
|-------|-----------|-------------|
| 1 | Equally Important | Both criteria participate equally to the goal |
| 3 | Weakly Important | Experience weakly favor of one criterion over another |
| 5 | Strongly Important | Experience strongly favor of one criterion over another |
| 7 | Very Strongly Important | Strong dominance of one criterion over another |
| 9 | Extremely Important | The preference of a criterion is of the highest possible value |
| 2,4,6,8 | Intermediate values between adjacent scales | When compromise is required |

The step by step procedure of AHP technique is described as follows:

**Step 1.** Construct the hierarchical structure of problem which contains the main criteria and the sub-criteria to evaluate the alternatives.

**Step 2.** Establish a pairwise comparison of criteria and construct a comparison matrix by using the information provided in Table 1. Assume that the decision problem is to be assessed on the basis of n criteria, then the pairwise comparison of criterion i with each criterion j yields a square matrix of order n × n. Each entry cij of matrix C provides the comparative value of criterion i with respect to criterion j. In the comparison matrix, the entry $c_{ij} = 1$ if and only if i = j and $c_{ij} = 1/c_{ij}$.

$$C_{n \times n} = \begin{bmatrix} C_{11} & \cdots & C_{1n} \\ \vdots & \ddots & \vdots \\ C_{(n-1)1} & \cdots & C_{(n-1)n} \\ C_{n1} & C_{n2} & C_{nn} \end{bmatrix} \qquad (1)$$

**Step 3.** Normalize the comparison values of decision matrix $c_{n \times n}$ by deploying the expression given in Equation (8), and construct a normalized decision matrix C_norm.

$$e_{ij} = c_{ij}/\sum_{j=1}^{n} c_{ij}, \quad i, j = 1,2,3,..n \qquad (2)$$

that is, each normalized entry is obtained by dividing each entry of column j by the sum of entries in column j. In the normalized decision matrix, the sum of entries in each column is 1.

**Step 4.** Calculate the weights of criteria by taking the average value of each row of normalized decision matrix as given in Equati follow:

$$\omega(i) = \sum_{j=1}^{n} e_{ij}/n \qquad (3)$$

As a result, a weight vector W satisfying the condition of normality is obtained in the form of column vector as follows,

$$w = \begin{bmatrix} \omega(1) \\ \omega(2) \\ \omega(3) \\ . \\ \omega(n) \end{bmatrix} \tag{4}$$

❑   The VIKOR method

The basic idea of the VIKOR technique, a MCDM method introduced by Opricovic (1998), consists of defining positive and negative ideal points to determine the relative distance of each alternative. After each relative distance is calculated, a weighted compromise ranking is obtained to determine the importance of the m alternatives available, $X_j$, with j = 1,2, ... , m. VIKOR provides a particularly effective tool in MCDM situations where the DM is unable ''to express his/her preference at the beginning of system design'' (Opricovic & Tzeng, 2004, p. 448). The compromise ranking algorithm is composed of the following steps:

**1.** Define the rating functions $f_{ij}$, which provide the value of the i-th criterion function for alternative $X_j$ with i = 1, 2, ... , n. Calculate the best, $f_i^+$, and the worst, $f_i^-$, values of all criterion functions. If the criterion being consider constitutes a benefit (i.e. it is a positive criterion), the corresponding values are defined as follows:

$$f_i^+ = max\left[(f_{ij})|j = 1.2 .... m\right] \tag{5}$$

$$f_i^- = min\left[(f_{ij})|j = 1.2 .... m\right] \tag{6}$$

**2.** Compute the values $S_j$ and $R_j$, j =1, 2,... , m, using the following relations.

$$S_j = \sum_{i=1}^{n} w_i \frac{(f_i^+ - f_{ij})}{(f_i^+ - f_i^-)} \tag{7}$$

$$R_j = max \left[ w_i \frac{(f_i^+ - f_{ij})}{(f_i^+ - f_i^-)} \right] \tag{8}$$

where $S_j$ and $R_j$ represent the group utility measure and the individual regret measure defined for each alternative $X_j$, respectively, and wi are the weights of the criteria that reflect their relative importance.

**3.** Compute the values $Q_j$, j = 1, 2, ... , m, using the relation.

$$Q_j = \vartheta \left[ \frac{(S_i - S^+)}{(S^- - S^+)} \right] + (1 - \vartheta) \left[ \frac{(R_j - R^+)}{(R^- - R^+)} \right] \tag{9}$$

Were

$$S^+ = Min\left[(S_j)|j = 1.2 .... m\right] \tag{10}$$

$$S^- = Max\left[(S_j)|j = 1.2 .... m\right] \tag{11}$$

**An Application to ABS**

In this research, our goal is to use two multi-criteria decision making methods. In this propose, there are six alternative (Indian Subcontinent, Middle East, Central Europe, GIS and Baltic, Southeast Asia, Nnortheast Asia) and six criteria (Car, Appliances, Electric, Building, Alloys, Other). In the first step, we obtain the weight of the Alternative through AHP method. Secondly, we rank the alternative through VIKOR method.

**Step 1:**

In this step, we will introduce criteria and alternatives.

| ABS market of countries | Car | Appliances | Electric | Building | Alloys | Other |
|---|---|---|---|---|---|---|
| Indian Subcontinent | 81 | 60 | 40 | 21 | 18 | 21 |
| Middle East | 63 | 56 | 53 | 34 | 25 | 28 |
| Central Europe | 40 | 37 | 21 | 20 | 10 | 9 |
| GIS and Baltic | 22 | 20 | 19 | 16 | 8 | 9 |
| Southeast Asia | 187 | 160 | 80 | 67 | 62 | 86 |
| Nnortheast Asia | 2973 | 1511 | 353 | 178 | 129 | 632 |

**Step2:** In this step, we create a pairwise comparison matrix through a Table 1.

| ABS market of countries | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_6$ |
|---|---|---|---|---|---|---|
| $A_1$ | 5 | 4 | 3 | 3 | 1 | 3 |
| $A_2$ | 4 | 2 | 8 | 3 | 3 | 3 |
| $A_3$ | 3 | 3 | 3 | 3 | 1 | 1 |
| $A_4$ | 1 | 1 | 1 | 1 | 1 | 1 |
| $A_5$ | 7 | 7 | 5 | 5 | 5 | 7 |
| $A_6$ | 9 | 9 | 7 | 7 | 7 | 9 |

**Step3:** Normalize the comparison values of decision matrix $c_{n \times n}$ ,that you can see in step 2. For example:

$$e_{11} = \frac{5 + 4 + 3 + 1 + 7 + 9}{6} = 0.17 \tag{12}$$

$$e_{12} = \frac{4 + 2 + 3 + 1 + 7 + 9}{6} = 0.14 \tag{13}$$

$$e_{13} = 0.11 \quad e_{14} = 0.13 \ldots\ldots e_{66} = 0.37 \tag{14}$$

**Step4:** Calculate the weights of criteria by taking the average value of each row of normalized decision matrix as given in Equati follow:

$$\begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ w_4 \\ w_5 \\ w_6 \end{bmatrix} = \begin{bmatrix} 0.121 \\ 0.152 \\ 0.09 \\ 0.037 \\ 0.197 \\ 0.325 \end{bmatrix} \tag{15}$$

**VIKOR method for ranking:**

**Step 1.** We form the $f_{ij}$ matrix and then obtain $f_i^+$ and $f_i^-$ .

|        | C₁    | C₂   | C₃   | C₄    | C₅    | C₆   |
|--------|-------|------|------|-------|-------|------|
| $f_i^+$ | 0.55  | 0.71 | 0.46 | 0.77  | 0.502 | 0.48 |
| $f_i^-$ | 0.162 | 0.17 | 0.14 | 0.106 | 0.301 | 0.31 |

Table2.

**2.** Compute the values $S_j$ and $R_j$:

| $S_j$ | $S_j = \sum_{i=1}^{n} w_i \dfrac{(f_i^+ - f_{ij})}{(f_i^+ - f_i^-)}$ |
|-------|-------------------------------------------------------------|
| $s_1$ | 0.299 |
|       |       |
| $s_2$ | 1.303 |
| $s_3$ | 0.237 |

| | |
|---|---|
| $s_4$ | 0.545 |
| $s_5$ | 0.456 |
| $s_6$ | 0.706 |

Table3.

$S_i^+ = 1.303$                $S_i^- = 0.299$

| $R_j$ | $R_j = max\left[w_i \dfrac{(f_i^+ - f_{ij})}{(f_i^+ - f_i^-)}\right]$ |
|---|---|
| $R_1$ | 0.120 |
| $R_2$ | 0.81 |
| $R_3$ | 0.09 |
| $R_4$ | 0.037 |
| $R_5$ | 0.197 |
| $R_6$ | 0.325 |

Table4.

$R_j^+ = 0.81$                $R_j^- = 0.09$

**3.** Compute the values $Q_j$.

$Q_1$=0.94   $Q_2$ =0   $Q_3$ =1   $Q_4$=0.885   $Q_5$=0.81   $Q_6$=0.61

Sort alternative by default Q, R, S

At this stage, the Q, R, S values are arranged in three groups from smaller to larger:

| Q | R | S | Q | R | S |
|---|---|---|---|---|---|
| 0 | 0.037 | 0.237 | $Q_2$ | $R_4$ | $S_3$ |
| 0.61 | 0.09 | 0.299 | $Q_6$ | $R_3$ | $S_1$ |
| 0.81 | 0.120 | 0.456 | $Q_5$ | $R_1$ | $S_5$ |

| 0.88 | 0.197 | 0.545 | $Q_4$ | $R_5$ | $S_4$ |
|------|-------|-------|-------|-------|-------|
| 0.91 | 0.325 | 0.706 | $Q_1$ | $R_6$ | $S_6$ |
| 1 | 0.81 | 1.303 | $Q_3$ | $R_2$ | $S_2$ |

Table5.

Finally, an option is selected as the best alternative that is recognized as the top alternative in all three groups. In group Q, the alternative is best if the following two condition are meet.

First condition:

$$Q(A_2) - Q(A_1) \geq \frac{1}{n-1} \tag{17}$$

$$Q(A_2) - Q(A_1) \geq \frac{1}{6-1} \ (0.2) \tag{18}$$

$$0.61 - 0 = 0.61 \geq 0.2 \tag{19}$$

Second condition:

Alternative $A_1$ must be the top option in at least one of the R and S groups. That this is not the case. When the condition is not met, the following set of options is recognized as the top rank.

$$Q(A_m) - Q(A_1) < \frac{1}{n-1} \tag{20}$$

When the second condition is not met, alternative $A_1$ and $A_2$ are recognized as the top rank.

**Conclusion**

Multiple criterion decision making (MCDM) refers to making decision in the presence of multiple, usually conflicting criteria. The problems of MCDM can be broadly classified into two categories: multiple attribute decision making (MDAM) and multiple objective decision making (MODM). In this research, we used the two method of MCDM for analysis of alternative. The Analytic Hierarchy Process (**AHP**) is a **method** for organizing and analyzing complex decisions, using math and psychology. It was developed by Thomas L. **AHP** provides a rational framework for a needed decision by quantifying its criteria and alternative options, and for relating those elements to the overall goal. The **VIKOR method** is a multi-criteria decision making (MCDM) or multi-criteria decision analysis method. It was originally developed by Serafim Opricovic to solve decision problems with conflicting and noncommensurable (different units) criteria, assuming that compromise is acceptable for conflict resolution, the decision maker wants a solution that is the closest to the ideal, and the alternatives are evaluated according to all established criteria. VIKOR ranks alternatives and determines the solution named compromise that is the closest to the ideal. In proposed, we get the weight vector of the criteria using the AHP method. Than, VIKOR method is performed to get the optimal preference ranking of the alternative. An this research, $A_1$ and $A_2$ are the best alternative for ABS market of countries. In the future researcher, the weight of criteria could also be obtained using different methods of MCDM and, on the other hand , we could we can used of DEA method for ranking alternatives.

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