# MULTI-CRITERIA ANALYSIS TO IMPROVE THE SERVICE IN GAS STATIONS

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**ABSTRACT**

In developing countries, oil consumption corresponds to 56% of total energy consumption. This generates competition between supply points, which are gas stations. Given the scarce differentiation between these supply points and low margins for sales, the strategy adopted by these service stations depends on the correct identification of both external and internal factors. In the present study, six multi-criteria techniques and a "strengths, weaknesses, opportunities and threats" (SWOT) analysis are proposed to quantitatively evaluate the factors that affect a specific network of gas stations. A total of two sets of results are obtained and it was determined for the chosen set of analysis that the recommended alternative is the improvement of training for personnel and image of the brand. The factor with the greatest weight is the low operational risk of compliance with emergency regulations. The differences in the results cause some factors to be more important than others and the proposed implementation to be contrary to expectations. The contribution of this study is the analysis of the performance of different multi-criteria tools in an actual case using the same data source.

**Keywords**: AHP; ANP; SWOT; gas stations; fuzzy logic; TOPSIS

## 1. Introduction

Fuel has a large impact on the productivity of a country. Because of the competition between different fuel suppliers, each of them adapt their resource allocations as efficiently as possible. These resource allocations depend, to a large extent, on the strategy adopted by each company. In a developing country, net consumption of oil derivatives can be close to 56%, and one part of the supply chain of this industry is the gas stations. The gas stations are facilities that supply fuel for vehicular use and heating to the public (Chima, 2007). These facilities offer various additional services that include car washing, motor lubricants, maintenance, convenience stores, tourist guides and electric motor recharging in addition to selling fuel. Therefore, those in charge must


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manage each of these services efficiently by designating positions according to the capabilities of the staff through a chart replicated in each of the locations.

One of the challenges of this type of company is defining a commercial strategy that is differentiated from the competition (Bello & Cavero, 2008). Strategic administration corresponds to all activities that allow for the long-term development of an organization with decisions based on future actions and the ability to identify both the internal and external environments of the organization (Bartusková & Kresta, 2015). Corporations are developed well with correct business administration in accordance with the environment (Gorëner et al., 2012a). Therefore, these strategies can improve both the position of the company itself within the sector and generate benefits for all companies of the sector.

In order to face the market efficiently, gas stations must evaluate their internal and external factors before defining the strategies to be implemented. The environment of a company can be identified through a strengths, weaknesses, opportunities and threats (SWOT) analysis, which intensifies the factors in different strategic criteria for greater support of the future decisions of the company (Gorëner et al., 2012b). It is necessary to correctly define the main objective (goal) of the company, the evaluation criteria and sub-criteria, and the alternatives or strategies to meet the objective (Wind & Saaty, 1980). Unfortunately, this method is not capable of quantifying the importance of the factors, thus making it difficult to assess their impact on the strategic decision (Mehmood et al., 2014). However, a quantitative evaluation method should be taken into account, such as a multi-criteria decision-making method (MCDM).

The selection of criteria is a multiple decision problem used in various industrial companies (Erdil & Erbiyik, 2015). The factors that impact organizational performance are quantified by comparison, and thus a strategy of continuous improvement is reached (Dulange et al., 2014). This method makes it possible to solve problems with a limited number of alternatives that require human participation because it depends on the knowledge of experts in a subject or sector (Kubler et al., 2016). However, the uncertainty of the selection of alternatives in a network of gas stations is because of the vagueness with which they are presented, which is based on subjective interpretations according to what is required by the specific company (Yussuff & Poh Yee, 2001). This allows the evaluator's points of view to affect the final results (Tavana et al., 2016). Therefore, it is required to consider the uncertainty as fuzzy.

## 2. Multi-criteria analyses

### 2.1 Analytic Hierarchy Process (AHP)

The AHP method is used for decision making based on paired comparisons between different alternatives that reflect the relative differences according to decision makers (Saaty, 1977). Its wider applications can be found in strategic planning, resource localization and conflict resolution (Saaty, 1987).

With the comparisons of each pair of factors, a matrix of comparisons is constructed and the values indicate the importance with which each element dominates the other with respect to an established criterion. This forms a matrix $A$ of $m \times n$ dimensions (see Equation 1), where $a_{ij}$ represents the priority between factor $i$ and factor $j$, and the reciprocal values of the lower half with respect to the diagonal correspond to the inverse values of the upper half ($a_{ji} = 1/a_{ij}$) are the values of the diag $a_{ij} = 1$ when $i = j$.

$$A = a_{ij} = \begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ a_{21} & 1 & \dots & a_{2n} \\ \vdots & \vdots & & \vdots \\ a_{m1} & a_{m2} & \dots & 1 \end{bmatrix} \tag{1}$$

First, the criteria comparison matrix (CCM) that must be normalized by means of Equations 2 and 3 is constructed. Then, the normalized comparison matrices of sub-criteria are obtained for each criterion (SCM) and the normalized comparison matrices of alternatives (ACM). Then, the vectors of the local weights are multiplied by the vector of weights of the criteria in order to obtain the vector of global weights of the sub-criteria, the vectors of weights of the alternatives for the vector of weights of the corresponding sub-criterion and the vectors of weights of the alternatives for the corresponding vector of weights of the sub-criterion in order to obtain the normalized local vectors of the alternatives according to each criterion (local NVA). Finally, the matrix of the local NVA is multiplied by the vector of weights of criteria to obtain the global normalized vector of alternatives (global NVA).

$$X_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \tag{2}$$

$$W_i = \frac{\sum_{j=1}^{n} X_{ij}}{n} \tag{3}$$

### 2.2 Technique for order performance by similarity to ideal solution (TOPSIS)

The TOPSIS method states that the best alternative must have the shortest distance with respect to the ideal positive solution (IPS) that minimizes the costs and maximizes the benefits, and have the greatest distance to the ideal negative solution (INS) that maximizes the costs and minimizes the benefits (Hwang & Yoon, 1981; Zhao & Fang, 2016).

To determine the weight of each criterion, the normalized vector $r_{ij} = a_{ij}/\sum_{i=1}^{n}\left(a_{ij}\right)^2$ is calculated from the elements $a_{ij}$ of the $A$ comparison matrix. Then, the entropy method $e_j = -\sum_{j=1}^{n} r_{ij} \ln r_{ij}/\ln n$ is used to decrease the effects of subjectivity, where $0 \leq e_j \leq 1$ and $n$ are the number of alternatives (Kim, 2016). The vector of weights $w_j = 1 - e_j/\sum_{j=1}^{m}(1 - e_j)$ indicates the weighting of the global weights of all sub-criteria of the study, where $m$ is the number of total criteria.

A standardized weight matrix is constructed according to $v_{ij} = w_j \times r_{ij}$. Then, an ideal positive solution $A*$ (4) and an ideal negative solution (Equation 5) are constructed, where $J_1$ is the set of criteria of costs, $v_j^*$ is the distance between the index $J$ and the closest value to the optimum, and $v_j^-$ is the distance between the index $J$ and the value farther from the optimum. The strengths and opportunities can be criteria of benefits and the weaknesses can be the criteria of costs.


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$$A^* = \{(\max_i a_{ij} \mid j \in J_1), (\min_i v_{ij} \mid j \in J_2), i = 1,2,\dots,m\} = v_1^*, v_2^*, \dots, v_n^* \quad (4)$$

$$A^- = \{(\min_i a_{ij} \mid j \in J_1), (\max_i v_{ij} \mid j \in J_2), i = 1,2,\dots,m\} = v_1^-, v_2^-, \dots, v_n^- \quad (5)$$

Then, the distance between the objective and the positive ideal solution ($d^* = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^*)^2}$) and the ideal negative solution ($d^- = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^-)^2}$) is calculated. Finally, the relative closeness with respect to the ideal solution $CC_i$ (6) where $0 \le CCi \le 1$. The higher the value of $CCi$, the greater preference a certain alternative has.

$$CC_i = \frac{\sum d_i^-}{\sum d_i^* + \sum d_i^-} \quad (6)$$

### 2.3 Analytic Network Process (ANP)

The ANP allows one to generalize the processes of paired comparisons (Saaty, 1996). According to this method, all elements can be determined by intertwined interactions in the same hierarchical level (cluster) or with others. As a result, a supermatrix is constructed. This is a matrix divided into segments where each segment represents a relation between two clusters in a system. Considering the fact that the SWOT analysis includes four clusters (goal, criteria, sub-criteria and alternatives), a supermatrix is proposed (Equation 7) which is similar to that proposed in the study by Yüksel & Dagdeviren (2007). The way in which the SWOT factors are interrelated can be observed in Figure 1 (Živković et al., 2015).

$$W = \begin{array}{c} \text{goal} \\ \text{factors} \\ \text{subfactors} \\ \text{alternatives} \end{array} : \begin{bmatrix} 0 & 0 & 0 & 0 \\ w_1 & W_2 & 0 & 0 \\ 0 & W_3 & 0 & 0 \\ 0 & 0 & W_4 & I \end{bmatrix} \quad (7)$$

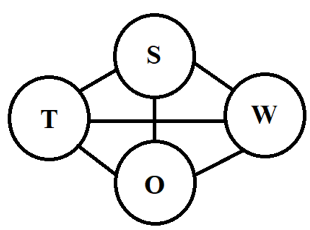


Figure 1 Interdependence between SWOT factors (Živković et al., 2015)

In Equation 7, $w_1$ is the vector that represents the impact of the general goal, $W_2$ is the matrix that represents the interdependence of the factors, $W_3$ is the matrix that denotes the impact of the factors on each of the sub-factors, and $W_4$ is the matrix that denotes the impact of the sub-factors in each alternative.

First, the matrix of comparisons of the SWOT factors ($w_1$) should be determined by assuming that there is no dependence among them and the interdependence of each

SWOT factor with respect to other factors ($W_2$). Then, the interdependent priorities of the factors must be calculated by multiplying $W_2$ by $w_1$ in order to determine the degrees of local importance of the sub-factors $w_{subfactor(local)}$ and to determine the degrees of global importance of the sub-factors $w_{subfactor(global)}$ by multiplying $w_{subfactor(local)}$ by $w_{factor}$. Finally, the importance degrees of the alternatives ($W_4$) with respect to each sub-criterion are determined and the global priorities of the alternatives are calculated by multiplying $W_4$ by $w_{subfactor(global)}$.

### 2.4 Fuzzy AHP (FAHP)

Fuzzy logic allows uncertain information to be presented through a triangular fuzzy number (TFN) (Zadeh, 1965). It is denoted as ($a$, $b$, $c$) so that ($a < b < c$), where $a$ is the lowest possible value, $b$ is the most promising value, and c is the highest possible value.

The FAHP method provides a range of values that incorporate the indecision of the decision makers. According to recent research, it is the second most widely used independent technique after AHP and its applications, and its applications have been diverse in various sectors such as manufacturing, industry, planning and resource allocation (Kubler et al., 2016; Rouyendegh & Erkan, 2012). The degree of possibility of each alternative is based on the extensive method of Chang (1996) and is used to evaluate fuzzy paired comparisons.

The matrix of fuzzy comparisons $\tilde{A}$ of dimensions $m \times n$ that contain all the paired comparisons $\widetilde{a_{ij}}$ is constructed between elements $i$ and $j$. Then, the geometric mean of the fuzzy comparative values of each criterion $\tilde{r}_i = \left(\prod_{j=1}^{n} \widetilde{a_{ij}}\right)^{1/n}$ is constructed. To determine the weights of the criteria and evaluate the alternatives, it is necessary to calculate the fuzzy weights of each criterion according to Equation 8.

$$\widetilde{r_1} = \left[(l_{11} * l_{12} * l_{13})^{\frac{1}{3}}; (m_{11} * m_{12} * m_{13})^{\frac{1}{3}}; (u_{11} * u_{12} * u_{13})^{\frac{1}{3}}\right] = [a_1; b_1; c_1] \tag{8}$$

Then, the sum vector is calculated from each $\tilde{r}_i$ so that $(\sum a_i, \sum b_i, \sum c_i)$. Thus, the inverse of each reordered element is determined so that the lowest value is in the first position and the highest value is in the last one. Thus, the fuzzy weight of each criterion $i$ ($\widetilde{w_i}$) is obtained by multiplying each $\tilde{r}_i$ by its reverse vector. Since $\widetilde{w_i}$ corresponds to fuzzy values, it is necessary for it to be "defuzzified" and converted into unique values ($M_i = \frac{a_i w_1 + b_i w_2 + c_i w_3}{3}$). Finally, the values are normalized. Then, by multiplying each weight of the alternatives to which they belong, the global scores of each alternative are obtained. Alternatives with higher scores suggest better results for the decision maker.

### 2.5 Fuzzy TOPSIS (FTOPSIS)

The FTOPSIS method is used to solve localization problems such as the selection of suppliers and the aspects of renewable energies and sustainability (Chen & Huang, 1992; Nadaban, 2016). It is usually combined with FAHP in the problems of the selection and evaluation of strategies (Nadaban, 2016). Assuming that there are $K$ members in the group, the fuzzy score of the $k$-th decision maker about alternative Ai with respect to


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criterion Cj is denoted as $\tilde{x}_{ij}^{k} = (a_{ij}^{k}, b_{ij}^{k}, c_{ij}^{k})$ (Equation 9). The weight of the criterion Cj is denoted as $\tilde{w}_{ij}^{k} = (w_{j1}^{k}, w_{j2}^{k}, w_{j3}^{k})$. Then, the "aggregate" fuzzy ranking $(a_{ij}, b_{ij}, c_{ij})$ of the *j*-th criterion must be calculated (Equation 10).

$$\left(a_{ij}, b_{ij}, c_{ij}\right) = \left(\min_{k}\{a_{ij}^{k}\}, \frac{1}{K}\sum_{k=1}^{K} b_{ij}^{k}, \max_{k}\{c_{ij}^{k}\}\right) \tag{9}$$

$$(w_{j1}, w_{j2}, w_{j3}) = \left(\min_{k}\{w_{j1}^{k}\}, \frac{1}{K}\sum_{k=1}^{K} w_{j2}^{k}, \max_{k}\{w_{j3}^{k}\}\right) \tag{10}$$

Then, the normalized fuzzy decision matrix is calculated as $\tilde{R} = [\tilde{r}_{ij}]$. If the criterion is a benefit, Equation 11 will be used. If the criterion is a cost, Equation 12 would be used.

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right);\ c_j^* = \max_{k}\{c_{ij}\} \tag{11}$$

$$\tilde{r}_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right);\ a_j^- = \min_{k}\{a_{ij}\} \tag{12}$$

With the above, the standardized fuzzy decision weight matrix is calculated. This matrix is denoted with $\tilde{V} = (\tilde{v}_{ij})$, where $\tilde{v}_{ij} = \tilde{r}_{ij} \times \tilde{w}_j$. Then, the fuzzy positive ideal solution (FPIS) (Equation 13) and the fuzzy negative ideal solution (FNIS) (14) are calculated.

$$A^* = (\tilde{v}_1^*, \tilde{v}_2^*, \dots, \tilde{v}_n^*),\ \ \tilde{v}_j^* = \max_{i}\{v_{ij3}\} \tag{13}$$

$$A^- = (\tilde{v}_1^-, \tilde{v}_2^-, \dots, \tilde{v}_n^-),\ \ \tilde{v}_j^- = \min_{i}\{v_{ij1}\} \tag{14}$$

Let $\tilde{x} = (a_1, b_1, c_1)$ and $\tilde{y} = (a_2, b_2, c_2)$. The distance between $\tilde{x}$ and $\tilde{y}$ is calculated according to Equation 15.

$$d(\tilde{x}, \tilde{y}) = \sqrt{\frac{1}{3}[(a_1 - a_2)^2 + (b_1 - b_2)^2 + (c_1 - c_2)^2]} \tag{15}$$

From each alternative $A_i$, the distance to FPIS and FNIS ($d_i^* = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^*)$ and $d_i^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^-)$) and the proximity coefficient of each alternative $CC_i = d_i^- / (d_i^- + d_i^*)$, which indicates which of all alternatives is the most preferred, are calculated.

To "defuzzify" the weights of the sub-criteria, the procedure from the study by Kacprzak (2017) is used. To represent the benefit criteria, the triangular positive values $(a_{ij}, b_{ij}, c_{ij})$ where $(a_{ij} \le b_{ij} \le c_{ij})$ are used. For the values of the cost criteria, the triangular negative values $(a_{ij}, b_{ij}, c_{ij})$ where $(a_{ij} \ge b_{ij} \ge c_{ij})$ are used. The steps to obtain the weights are described as follows. First, build a fuzzy decision matrix with


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"aggregate" fuzzy scores while considering if they are criteria of benefits or costs. Then, normalize the matrix of the previous step with the elements $(a_{ij}^N, b_{ij}^N, c_{ij}^N)$. After that, construct the entropy fuzzy vector $e_j$ (Equation 16), where $m$ is the number of alternatives and calculate the fuzzy vector of weights of each file as a value of "the fuzzy vector of weights of criteria $w_j$" (Equation 17), where $n$ is the number of sub-criteria. Finally, select the central value of the fuzzy vector of weights in each row as a value of the "defuzzified" weight of each criterion.

$$e_j = \left(-\frac{\sum_{i=1}^{m} a_{ij}^N}{\ln m} \ln a_{ij}^N = e_{j(0)}, -\frac{\sum_{i=1}^{m} b_{ij}^N}{\ln m} \ln b_{ij}^N = e_{j(1)}, -\frac{\sum_{i=1}^{m} c_{ij}^N}{\ln m} \ln c_{ij}^N = e_{j(2)}\right) \tag{16}$$

$$w_j = \left(\frac{1-e_{j(0)}}{\sum_{i=1}^{n}(1-e_{j(0)})}, \frac{1-e_{j(1)}}{\sum_{i=1}^{n}(1-e_{j(1)})}, \frac{1-e_{j(2)}}{\sum_{i=1}^{n}(1-e_{j(2)})}\right) \tag{17}$$

**2.6 Fuzzy ANP (FANP)**

FANP analysis includes both the interdependence of criteria and the internal dependence of criteria within the matrix of comparison, which corresponds to a combination of the ANP and AHP methods, with fuzzy parameters (Reza et al., 2016). In the model suggested for the analysis in this study, the following steps are included.

- Determine the local weights of the criteria and sub-criteria of each alternative by assuming that there are no internal dependencies from the Saaty fuzzy scale.
- Determine the fuzzy scale of the interdependence matrix of each factor with respect to the other factors in each alternative. This matrix is multiplied by the local weights to obtain the interdependence weights of the factors.
- Calculate the total weights of the sub-factors in each alternative. The global steps of sub-factors are calculated by multiplying the local weights of the sub-factors with the interdependence weight of the factor to which they belong.
- Determine the importance of each alternative through a ranking.

## 3. Literature review

There are several studies that combine multi-criteria techniques with a SWOT matrix. In Görener et al. (2012), an AHP-SWOT matrix is proposed to determine the priorities of both internal and external factors of a kitchen hood company in Turkey. In the study by Mehmood et al. (2014), they determined the most effective factors to adopt a specific cell phone technology in an Italian company. Erdil & Erbiyik (2015) determined the best development strategy for a dairy company in Turkey. Moreover, the study by Yüksel & Dagderiven (2007) showed a process to quantify the SWOT matrix with dependence among other strategic factors in a textile company in Turkey. Görener (2012) proposed an improvement to the SWOT matrix with the AHP-ANP method in a manufacturing company also in Turkey and used both methods in the prioritization of SWOT factors and the analysis of the differences in their results with the indicated interdependencies.

The study by Živković et al. (2015) used the ANP-SWOT method to generate SWOT strategies in the case of a technical college in Serbia. Zare et al. (2015) presented a


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SWOT matrix to evaluate the supply chain of electricity in a region of Iran. The AHP method was integrated with FTOPSIS as a proposal to prioritize the SWOT factors. The results show that the proposed method can be used to determine the strategic plan with high prioritization for planning and decision making in the supply chain. Tavana et al. (2016) proposed an FAHP method to identify the decision criteria in the selection of the best suppliers for an outsourcing company through a programmatic model in order to produce local and global weights and thus create a global ranking. Islam et al. (2017) implemented the SWOT analysis together with TOPSIS in order to find the best strategy inside a pharmaceutical company in Bangladesh and the ranking of each of the criteria in the SWOT matrix was performed.

By using combined methods, Ervural et al. (2017) proposed a hybrid method for the analysis of the energy sector in Turkey with SWOT, ANP and TOPSIS to formulate and analyze the alternatives of energy strategies and their priorities. This method makes it possible to identify the relevant criteria and sub-criteria by using SWOT, then ANP to determine the weights of each factor, and finally FTOPSIS to prioritize the alternatives. Shahba et al. (2017) applied an AHP-TOPSIS method and SWOT factors and strategies for waste management iron mines in Iran. The ranking of factors was qualitatively determined, where AHP was used to calculate the weight of the criteria and TOPSIS was used to take advantage of their ability to use both negative and positive criteria.

From the literature review, it can be concluded that fuzzy logic allows one to eliminate or diminish the problems of classical logic by reducing the uncertainty of decisions and the imprecision in the companies due to the number of experts involved in the lifecycle of the product (from designers to final sellers) (Kubler et al., 2016). This also increases the complexity of the judgments of the experts. In addition, multi-criteria decision methods are very versatile. They are used in various types of industries globally or locally, in small or large companies, and in manufacturing or services, and they can be applied together to determine the order of preference according to the conditions of the company. For this reason, this work aimed to identify the most important factors of a network of gas stations through SWOT analysis and quantitatively analyzed different multi-criteria techniques, such as classical logic and fuzzy logic, in order to compare the results of their weightings and to determine the most appropriated method for global evaluations.

## 4. Methodology

### 4.1 SWOT analysis

The SWOT analysis is the most popular method used in strategic analysis (Tavana et al. 2016). It identifies the internal and external factors of an organization, which are known as strengths, weaknesses, opportunities and threats. With this analysis, it is possible to build the SWOT matrix and define the strategies (alternatives) with each pair of factors: SOs (Strengths-Opportunities), which require a good use of the opportunities by using the existing strengths in the organization; WOs (Weakness-Opportunities), which obtain the benefits from external opportunities by considering the weaknesses of the organization; STs (Strengths-Threats), which use the strengths of the organization and remove or reduce the effects of the threats; and WTs (Weaknesses-Threats), which consider the efforts of the company to reduce the effects of threats by considering the weaknesses.


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**4.2 Surveys**

A survey was prepared for a population of executives (7 in total), and it contained three sections. The first section was for AHP and FAHP and contained two parts and 210 questions, including the comparison of each criterion/sub-criterion with respect to the others and a comparison of SWOT alternatives considering each sub-criterion. The second section was for TOPSIS and FTOPSIS. It also had two parts and 120 questions to evaluate the importance of each sub-criterion with respect to the global goal and to evaluate the importance of each alternative with respect to each sub-criterion. Finally, the third section of the survey was for ANP and FANP and considered 12 questions to evaluate the internal dependencies among the factors and consider the importance of each factor over another.

The respondents marked some of the cells indicated in the numbered columns (1 to 5). The more distant it was from the center of the table, the greater the degree of importance that criterion had over the other. If there was any doubt, the mark could be placed between two adjacent columns. The meaning of each value that corresponds to the reciprocal value and the values converted to the Saaty scale and fuzzy scale can be seen in Table 1. All of the executives responded to the survey, where ($DE_i$) is the population of executives surveyed and $i$ is the number of administrators of the gas station network.

Table 1
Saaty survey scale (Saaty, 1987)

| Survey | Significance | Saaty | Reciprocal | Fuzzy | | | Reciprocal | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Equally important | 1 | 1 | 1 | 1 | 3 | 1/3 | 1 | 1 |
| 1.5 | Between 1 and 2 | 2 | ½ | 1 | 2 | 4 | 1/4 | 1/2 | 1 |
| 2 | Relative importance | 3 | 1/3 | 1 | 3 | 5 | 1/5 | 1/3 | 1 |
| 2.5 | Between 2 and 3 | 4 | ¼ | 2 | 4 | 6 | 1/6 | 1/4 | ½ |
| 3 | Strong importance | 5 | 1/5 | 3 | 5 | 7 | 1/7 | 1/5 | 1/3 |
| 3.5 | Between 3 and 4 | 6 | 1/6 | 4 | 6 | 8 | 1/8 | 1/6 | ¼ |
| 4 | Very strong importance | 7 | 1/7 | 5 | 7 | 9 | 1/9 | 1/7 | 1/5 |
| 4.5 | Between 4 and 5 | 8 | 1/8 | 6 | 8 | 9 | 1/9 | 1/8 | 1/6 |
| 5 | Absolute importance | 9 | 1/9 | 7 | 9 | 9 | 1/9 | 1/9 | 1/7 |

**4.3 Multi-criteria analysis**

Since the ratings are subjective (and there are inconsistencies in the chosen decisions) from the consistency vector per the obtained matrix (Equation 18), the measure of consistency is calculated as $\lambda_{max} = \sum_{i=1}^{n} Cv_{ij}/W_i$.

$$\begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} * \begin{bmatrix} W_1 \\ W_2 \\ W_3 \end{bmatrix} = \begin{bmatrix} Cv_1 \\ Cv_2 \\ Cv_3 \end{bmatrix} \tag{18}$$

Then, the consistency index is calculated by $CI = \frac{\lambda_{max}-n}{n-1}$, which reflects the consistency of the judgments of each decision maker. Finally, the consistency ratio $CR = CI/IA$ is


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calculated. In it, if CR = 0, the matrix is consistent; if CR ≤ 0.1, the matrix has an acceptable consistency; and if CR > 0.1, the matrix has an inadmissible consistency and the paired comparisons must be reevaluated. IA is the consistency index of a random matrix of order *n*, which is obtained depending on the size of the matrix (*n*). Data consistency was performed for each of the comparison matrices and obtained from each respondent for the AHP and ANP analyses, except for TOPSIS in which no paired assessments are considered.

Once all of the experts had delivered their results ($k = 1 \ldots m$ experts), each provided its own result ($a_{ij}^{k}$) on the relative importance of a criterion over another. The global preference of that specific comparison was obtained with Equation 19, where *i* corresponded to the question, *j* to the respondent and *n* to the total number of respondents. For the values of fuzzy logic, Equation 20 is used. Then, it is possible to calculate the weights of the criteria and the scores of the alternatives according to the steps of each multi-criteria analysis.

$$a_{ij}^{global} = \prod_{k=1}^{m} (a_{ij}^{k})^{1/m} \tag{19}$$

$$\left(l_{ij}, m_{ij}, u_{ij}\right)_{global} = \left(\prod_{k=1}^{m} (l_{ij}^{k})^{1/m}, \prod_{k=1}^{m} (m_{ij}^{k})^{1/m}, \prod_{k=1}^{m} (u_{ij}^{k})^{1/m}\right) \tag{20}$$

**4.4 Analysis of alternatives and sub-criteria**

A ranking of alternatives and global weights of sub-criteria was constructed. The analysis of alternatives involves comparing the obtained results, determining sets of analysis with similar results and observing which alternatives have the greatest preference. The analysis of global weights is demonstrated in a graph where the line in each quadrant represents the global importance of each group and each point represents the global priorities of each individual factor (Mehmood, et al., 2014). If there are more points close to the final edge of the line, the criterion that includes them is considered more influential.

To determine the influence of each sub-criterion in the sequence of alternatives of each set, a sequence table was defined, and obtained from the alternative scores for each sub-criterion, which is compared with the sequence of alternatives of each set. The greater the similarity of the preferred alternatives, the greater influence the sub-criterion has in the average sequence of each set, and therefore greater consideration should be given to that sub-criterion.


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## 5. Results

Both the criteria and sub-criteria are defined in Table 2 based on the indicators defined by the decision makers.

Table 2
Criteria and sub-criteria

| Criteria | Initial | Sub-criteria |
|---|---|---|
| Strengths (S) | S1 | Predictable long-term revenue stream. |
| | S2 | Integrated management between administrators and owners. |
| | S3 | Accurate control of fuel sales. |
| | S4 | Brand support, technical and operational. |
| | S5 | Staff has years of experience and low turnover. |
| | S6 | Low operational risks. |
| Weaknesses (W) | W1 | Very variable fuel order volume. |
| | W2 | External financing for the payment of credits. |
| | W3 | Low profit margins. |
| | W4 | Lack of staff training of the attendants. |
| | W5 | Possibility of loss of money by staff. |
| | W6 | High dependence on suppliers. |
| Opportunities (O) | O1 | High demand for fuel. |
| | O2 | Reduced conflicts of workers' union. |
| | O3 | Station location in crowded places. |
| | O4 | Generation of other types of businesses in addition to fuel. |
| | O5 | Generates great circulation of people. |
| | O6 | Field sales to companies outside the station. |
| Threats (T) | T1 | High external and internal competition (same brand). |
| | T2 | Low differentiation of service with respect to the competition. |
| | T3 | Needs of vehicles with alternative energy sources. |
| | T4 | Direct sales from the oil providers. |
| | T5 | Assault risk. |
| | T6 | Price increases and customer decisions. |

With the sub-criteria, it was possible to define four alternatives to guide the decisions of the company. These are shown in the SWOT matrix (Table 3).

Table 3
SWOT matrix and alternatives

| Criteria | Strengths | Weaknesses |
|---|---|---|
| Opportunities | SO: Company expansion through alternative business other than automobile services | WO: Improve personnel training (attention and image) |
| Threats | ST: Improve facility security to prevent theft | WT: Differentiation of service for all types of vehicles |


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According to the consistency analysis for both the AHP and ANP methods, all the decision makers obtained an average consistency ratio of less than 0.1, thus verifying that all decision makers comply with an acceptable inconsistency. In Table 6 (see Appendix), the CR values of each decision maker ($DE_i$) are displayed.

The results of each methodology (Table 7, see Appendix) are classified into two groups. In the first group, the analyses AHP-FAHP-ANP-FANP (hierarchical order analysis: set 1) agree that the order of alternatives is WO (0.295) > SO (0.281) > ST (0.252) > WT (0.172). In the second group, the TOPSIS-FTOPSIS analyses (preferential order analysis: set 2) agree that the order of alternatives is SO (0.288) > WO (0.258) > ST (0.246) > WT (0.208). The average standard deviation of set 1 is 0.003 and is 0.095 for set 2. Table 8 (see Appendix) shows the sub-criterion weight values for each applied method.

## 6. Discussion

Figure 2 shows the results of the global weights of the sub-criteria calculated according to each set in order to reduce the data's standard deviation from Table 8. The main difference in the results of the scores of the alternatives is the position of the alternative WO, which ranks first in set 1 and second in set 2. While analyses AHP-FAHP-ANP-FANP (hierarchical order: set 1) compare each possible paired combination, analyses TOPSIS-FTOPSIS (preferential order: set 2) only require one to know the general preference of a factor and/or alternative without considering the others. Given this, some factors are more important for a certain set and less important in others. If decision makers consider only set 1, the best alternative would be WO, but if they only consider set 2, the alternative would be SO.

In Figure 2a, the maximum lengths in each quadrant are S6 (0.089), W3 (0.045), O1 (0.083) and T5 (0.032). Both the strengths and opportunities have more weight than weaknesses and threats because each length of the benefit criteria is greater and its points are better distributed towards the outer end of the line. In Figure 2b, the maximum lengths in each quadrant are S3 (0.095), W5 (0.082), O2 (0.064) and T5 (0.091). It is not clear whether the benefit criteria outweigh the cost criteria since the strengths have points that are distributed close to the central axis and the opportunities have the shortest length of all quadrants. Each set can generate different distributions of preferences among themselves despite corresponding to the same population of respondents.


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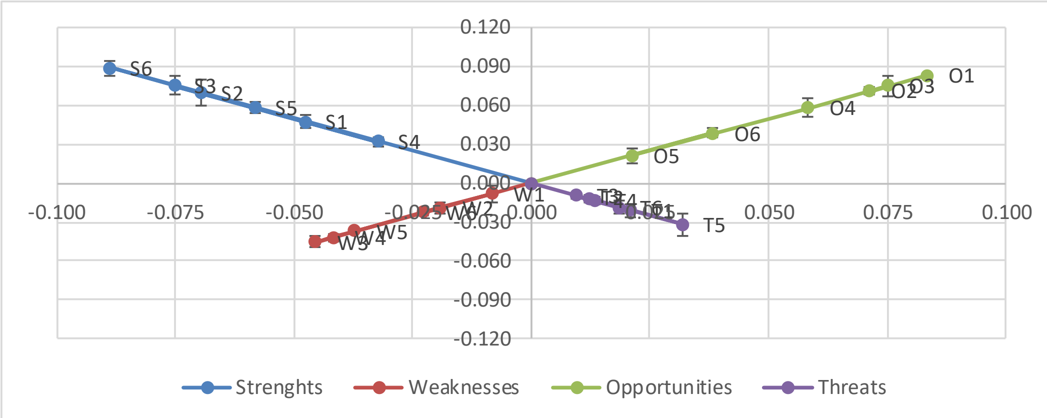
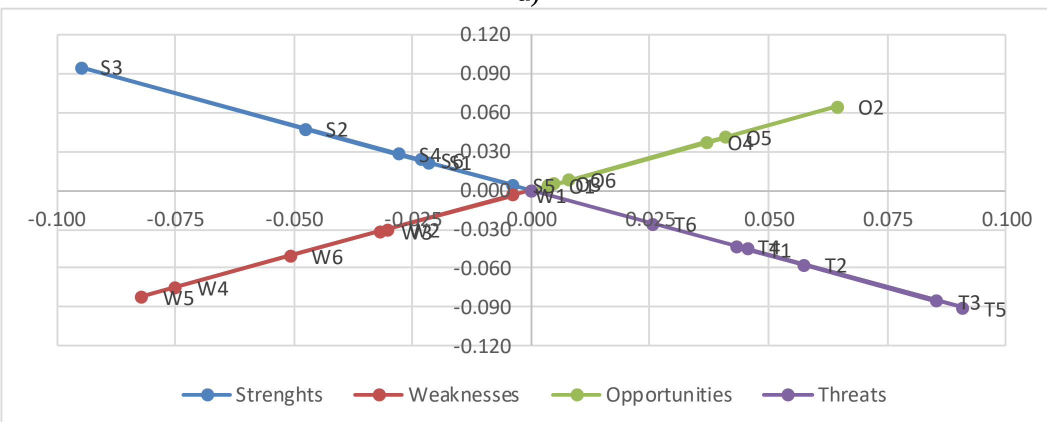



a)




b)

Figure 2 Graphical representations of the average global weights of the sub-criteria according to each set: a) Results obtained for set 1, and b) Results obtained for set 2

The selection of a multi-criteria analysis must be made with caution because the strategic guidelines in the company are defined from these sub-criteria. This is important because in practice this could lead to different effects than those considered. In addition, according to the chosen set, there are some sub-criteria with sequences similar to the average sequence of alternatives. Those with greater similarity could exert a greater influence in the average sequence of alternatives of each set and could be determinants when defining strategies apart from the sub-criteria with the highest global and local scores.

Table 4 shows, for each sub-criterion, which set obtains the greatest global and local percentage and which set has the greatest influence in the sequence of average alternatives. It indicates which alternatives have coincidences in each set, the positions (locations) of these alternatives and which set has the greatest importance in the average sequence.

S1, S2, S3, S6, W2, O1, O3, O4, O6 and T4, despite having greater global weights using a certain set, have importance in the sequence of alternatives of the opposite set. In these cases, the order of alternatives of the same set is not influenced by a greater global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percentage. T2, T3 and T6, despite having greater global weights using a certain set, generate no greater influence in the average order. In the rest of the sub-criteria, the set with the greatest global percentage coincides with the average order: S4, S5 and O2 using set 1, and W3, W4, W5, W6, O5, T1 and T5 using set 2. These last sub-criteria should be considered when selecting some set for this problem because they have greater agreement with the global preferences of the alternatives of each set. The last row corresponds to data in Table 9 (see Appendix), and shows the set with greater similarity of all sub-criteria with respect to average sequences.


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Table 4
For each sub-criteria, the set with the highest global and local percentage, and the set with the greatest influence on the average sequence of alternatives

| Sub-criteria | Set 1 (%) | | Set 2 (%) | | Set with highest global % | Set with highest local % | Set with the greatest influence on alternatives (Table 9) |
|---|---|---|---|---|---|---|---|
| | RL | RG | RL | RG | | | |
| S1 | 12.8 | 4.8 | 9.8 | 2.2 | 1 | 2 | 2 |
| S2 | 18.7 | 7.0 | 21.7 | 4.8 | 1 | 2 | 2 |
| S3 | 20.2 | 7.5 | 43.3 | 9.5 | 2 | 2 | 1 |
| S4 | 8.7 | 3.2 | 12.7 | 2.8 | 1 | 2 | 1 |
| S5 | 15.7 | 5.8 | 1.8 | 0.4 | 1 | 1 | Similar |
| S6 | 23.9 | 8.9 | 10.6 | 2.3 | 1 | 1 | 2 |
| W1 | 4.8 | 0.8 | 1.4 | 0.4 | 1 | 1 | Neither |
| W2 | 11.0 | 1.9 | 11.1 | 3.0 | 2 | 2 | 1 |
| W3 | 26.0 | 4.5 | 11.7 | 3.2 | 1 | 1 | 1 |
| W4 | 23.9 | 4.2 | 27.3 | 7.5 | 2 | 2 | 2 |
| W5 | 21.3 | 3.7 | 30.0 | 8.2 | 2 | 2 | Same |
| W6 | 13.0 | 2.3 | 18.6 | 5.1 | 2 | 2 | 2 |
| O1 | 24.0 | 8.3 | 2.2 | 0.4 | 1 | 1 | 2 |
| O2 | 20.5 | 7.1 | 40.6 | 6.4 | 1 | 2 | 1 |
| O3 | 21.6 | 7.5 | 3.1 | 0.5 | 1 | 1 | 2 |
| O4 | 16.8 | 5.8 | 23.3 | 3.7 | 1 | 2 | 2 |
| O5 | 6.1 | 2.1 | 25.7 | 4.1 | 2 | 2 | 2 |
| O6 | 11.0 | 3.8 | 5.0 | 0.8 | 1 | 1 | 2 |
| T1 | 19.7 | 2.1 | 13.1 | 4.6 | 2 | 1 | Similar |
| T2 | 11.4 | 1.2 | 16.5 | 5.7 | 2 | 2 | Neither |
| T3 | 8.9 | 0.9 | 24.5 | 8.6 | 2 | 2 | Neither |
| T4 | 12.5 | 1.3 | 12.4 | 4.3 | 2 | 1 | 1 |
| T5 | 30.0 | 3.2 | 26.1 | 9.1 | 2 | 1 | 2 |
| T6 | 17.5 | 1.9 | 7.4 | 2.6 | 2 | 1 | Neither |

In Table 5, the main disadvantages of each of the analyses are detailed from the data in Table 10 (see Appendix). Based on this, for this case it is not recommended to use the methodologies from set 2 because several sub-criteria have similar values to each other (Figure 2b), thus preventing the clear identification of any criterion being superior to the rest, and the deviation of the results compared with set 1. In addition, the definition of the SWOT sub-criteria may not be evident due to the uncertainty of the administrators themselves. This could require reevaluating a new set of factors and verifying new values of alternatives of greater proximity between set 1 and set 2.

The global ranking of sub-criteria according to the sub-criteria of set 1 is shown in Figure 3 and is defined as the set of analyses used for decision making in the study.


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Table 5
Main disadvantages of each analysis

| Analysis | Main disadvantages |
|---|---|
| AHP-FAHP | It requires paired comparisons by each decision-maker on the criteria, sub-criteria and alternatives and compliance with a maximum consistency ratio of 10%. The preferences are more restricted. |
| ANP-FANP | The ANP increased the threats (21%), while the rest only slightly changed (approximately 4%). The FANP increased the strengths (14%), reduced the weaknesses (40%), increased the opportunities (11%) and reduced the threats (53%). However, the changes do not generate significant deviations in the analyses of set 1. Thus, they are a complement to AHP-FAHP in this study. |
| TOPSIS-FTOPSIS | They only require preferences of each sub-criterion (only applies in FTOPSIS) and preferences of each alternative over each sub-criterion, thereby being the least complex technique in this study. In addition, the standard deviation of the global alternatives scores is higher. This causes the averaged weight of sub-criteria to be very different from set 1 (Table 10). For example, differences greater than 200% are seen in the threats, which may be triggered by the subjectivity. |

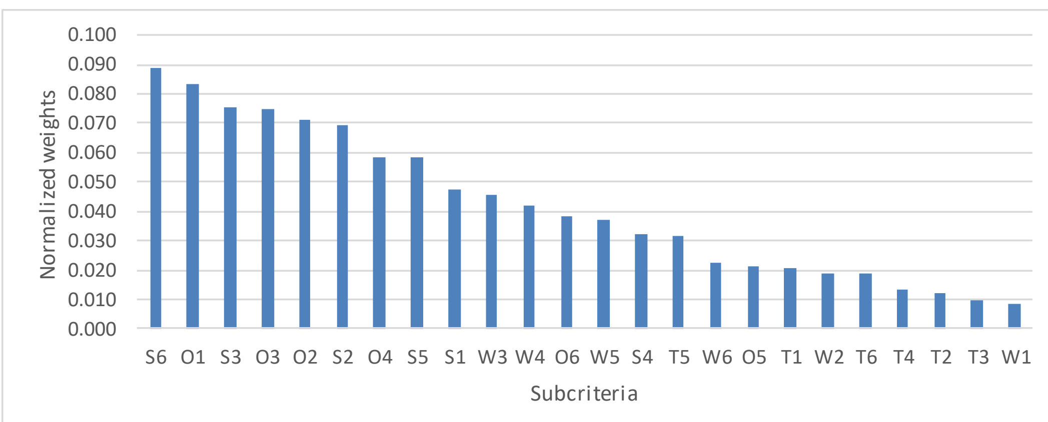


Figure 3 Final global ranking of the sub-criteria

The distribution of factors indicates a high tendency for strengths and opportunities and a low tendency for weaknesses and threats. The sub-criteria with the greater weight for each criterion are: S6, O1, W3 and T5; whereas the sub-criteria with the lowest weight for each criterion are: S4, O5, T3 and W1. In addition, S4 (14$^{th}$ place), S5 (8$^{th}$ place) and O2 (5$^{th}$ place) are the factors with the greatest similarity in the sequence of alternatives (according to Table 9). Although the strengths and opportunities are stronger than the weaknesses and opportunities, the WO was the one that obtained a greater preference. Then, weaknesses and opportunities should be globally stronger than the rest. Finally, the contribution of this study is the analysis of how the different multi-criteria analyses perform in an actual case using the same population of interviewees where the results are very different from each other.

## 7. Conclusions

The consumption of oil in a developing country generates high competition within the last link of the supply chain which is gas stations. The allocation of the resources of each gas station depends on the strategy adopted by the company, and one of the challenges of these companies is to select the appropriate strategy. Several multi-criteria decision-making techniques (MCDM) are proposed in this study in order to improve the service provided by these companies. AHP, TOPSIS, ANP, FAHP, FTOPSIS and FANP were used with FODA analysis to determine the preferences of the alternatives and weights of sub-criteria in a company that manages a network of gas stations.

Through a service, the administrators of this company evaluated these factors comparatively. With six multi-criteria analyses, differences in the sequence of alternatives were observed. In the AHP-FAHP-ANP-FANP analyses (hierarchical order, set 1), the following sequence was obtained: WO > SW > WT > DA. In the TOPSIS-FTOPSIS analyses (preferential order, set 2) the sequence was SW >WO > WT > DA. The difference in how the analyses collect information is as follows. In set 1, each possible paired combination is compared, and in set 2, it is only the intrinsic preference of each factor and/or alternative that must be known, which causes some factors to be more important for one set of analyses than others.

Regarding sub-criteria in set 1, the strengths and opportunities have more weight than the weaknesses and threats. In set 2, it has not been determined if the benefit criteria have a greater weight than the cost criteria or vice versa. Each set generates a distribution of preferences, which is different despite originating in the same population of respondents. The choice of a multi-criterion analysis should be made with caution because when implementing the results in reality the effects are often different than expected. In addition, according to the chosen set, some sub-criteria have sequences that closely resemble the average sequence of alternatives. Those with greater similarity would exert a greater influence in the average sequence of alternatives of each set that could be determined when defining strategies. Specifically, this occurs with S4, S5 and O2 (using set 1) and W3, W4, W5, W6, O5, T1 and T5 (using set 2). When considering choosing one of these sets for the problem, they have greater concordance with the global preference of alternatives of each set.

In relation to the advantages of the studied methods, it is not recommended to use the methodologies of set 2 for this case because they are less precise about the sub-criteria. Therefore, set 1 was defined for decision making and the preferred alternative is WO (the improvement of training for the staff and the brand's image). The sub-criteria with the greatest weight of each criterion are: S6, O1, W3 and T5; whereas the sub-criteria with the lowest weight for each criterion are: S4, O5, T3 and W1. In addition, S4 ($14^{th}$ place), S5 ($8^{th}$ place) and O2 ($5^{th}$ place) are the factors with the greatest similarity in the sequence of alternatives. Despite that, the strengths and weaknesses were stronger than the weaknesses and threats. WO was the most selected alternative. Then, weaknesses and


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opportunities should be globally stronger than the rest. In addition, the contribution of this study is the analysis of how the different multi-criteria analyses perform in a real case from the same population of interviews where the results are very different from each other.

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# APPENDIX

Table 6
Average consistency ratio (CR) and standard deviation (AHP, ANP) of each decision maker $DE_i$

| Decision maker | CR (AHP) | $\sigma$ | CR (ANP) | $\sigma$ |
|---|---|---|---|---|
| $DE_1$ | 0.083 | 0.019 | 0.030 | 0.020 |
| $DE_2$ | 0.082 | 0.022 | 0.060 | 0.041 |
| $DE_3$ | 0.080 | 0.012 | 0.092 | 0.006 |
| $DE_4$ | 0.077 | 0.019 | 0.055 | 0.028 |
| $DE_5$ | 0.091 | 0.005 | 0.052 | 0.049 |
| $DE_6$ | 0.080 | 0.029 | 0.048 | 0.044 |
| $DE_7$ | 0.082 | 0.017 | 0.085 | 0.011 |

Table 7
Final results, arithmetic means and standard deviations according to each analysis

| Alter. | AHP | FAHP | TOPSIS | FTOPSIS | ANP | FANP | $\bar{X}$ | $\sigma$ |
|---|---|---|---|---|---|---|---|---|
| SO | 0.281 | 0.281 | 0.275 | 0.302 | 0.280 | 0.284 | 0.284 | 0.009 |
| WO | 0.291 | 0.298 | 0.265 | 0.251 | 0.291 | 0.297 | 0.282 | 0.020 |
| ST | 0.252 | 0.250 | 0.252 | 0.240 | 0.251 | 0.253 | 0.250 | 0.005 |
| WT | 0.176 | 0.171 | 0.208 | 0.208 | 0.178 | 0.166 | 0.184 | 0.019 |


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Table 8
Global sub-criterion weights, means and standard deviations according to each analysis

| Sub-criteria | AHP | FAHP | TOPSIS | FTOPSIS | ANP | FANP | $\bar{X}$ | $\sigma$ |
|---|---|---|---|---|---|---|---|---|
| S1 | 0.045 | 0.047 | 0.018 | 0.021 | 0.022 | 0.054 | 0.038 | 0.014 |
| S2 | 0.063 | 0.072 | 0.040 | 0.048 | 0.047 | 0.083 | 0.060 | 0.016 |
| S3 | 0.072 | 0.075 | 0.080 | 0.095 | 0.095 | 0.085 | 0.077 | 0.005 |
| S4 | 0.031 | 0.032 | 0.023 | 0.028 | 0.028 | 0.037 | 0.029 | 0.005 |
| S5 | 0.057 | 0.057 | 0.003 | 0.004 | 0.004 | 0.065 | 0.040 | 0.026 |
| S6 | 0.089 | 0.085 | 0.020 | 0.023 | 0.023 | 0.097 | 0.066 | 0.033 |
| W1 | 0.009 | 0.009 | 0.003 | 0.004 | 0.004 | 0.006 | 0.007 | 0.003 |
| W2 | 0.019 | 0.022 | 0.025 | 0.030 | 0.030 | 0.016 | 0.021 | 0.004 |
| W3 | 0.050 | 0.047 | 0.027 | 0.032 | 0.032 | 0.033 | 0.039 | 0.011 |
| W4 | 0.045 | 0.044 | 0.107 | 0.074 | 0.076 | 0.031 | 0.064 | 0.032 |
| W5 | 0.040 | 0.039 | 0.117 | 0.082 | 0.082 | 0.028 | 0.064 | 0.038 |
| W6 | 0.024 | 0.024 | 0.110 | 0.051 | 0.051 | 0.017 | 0.052 | 0.042 |
| O1 | 0.081 | 0.083 | 0.003 | 0.004 | 0.004 | 0.092 | 0.057 | 0.038 |
| O2 | 0.070 | 0.070 | 0.054 | 0.065 | 0.064 | 0.078 | 0.066 | 0.009 |
| O3 | 0.074 | 0.074 | 0.004 | 0.005 | 0.005 | 0.082 | 0.051 | 0.034 |
| O4 | 0.060 | 0.055 | 0.031 | 0.037 | 0.037 | 0.062 | 0.049 | 0.013 |
| O5 | 0.021 | 0.021 | 0.034 | 0.041 | 0.041 | 0.023 | 0.026 | 0.006 |
| O6 | 0.040 | 0.035 | 0.007 | 0.008 | 0.008 | 0.039 | 0.028 | 0.015 |
| T1 | 0.021 | 0.022 | 0.038 | 0.046 | 0.046 | 0.014 | 0.027 | 0.009 |
| T2 | 0.012 | 0.013 | 0.049 | 0.058 | 0.057 | 0.008 | 0.024 | 0.017 |
| T3 | 0.009 | 0.010 | 0.072 | 0.086 | 0.085 | 0.007 | 0.030 | 0.029 |
| T4 | 0.014 | 0.014 | 0.036 | 0.043 | 0.043 | 0.009 | 0.021 | 0.011 |
| T5 | 0.034 | 0.031 | 0.076 | 0.090 | 0.091 | 0.021 | 0.047 | 0.022 |
| T6 | 0.020 | 0.018 | 0.022 | 0.026 | 0.026 | 0.012 | 0.020 | 0.004 |


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Table 9
Sequence of alternatives in each set according to each sub-criteria and global orden

| Sub-criteria | Global | | S1 | | S2 | | S3 | | S4 | | S5 | | S6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Set* | *1* | *2* | *1* | *2* | *1* | *2* | *1* | *2* | *1* | *2* | *1* | *2* | *1* | *2* |
| SO | 2 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 3 | 1 | 1 | 1 |
| WO | 1 | 2 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 2 |
| ST | 3 | 3 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 3 | 4 |
| WT | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 4 | 4 | 4 | 3 |
| Sub-criteria | Global | | W1 | | W2 | | W3 | | W4 | | W5 | | W6 | |
| *Set* | *1* | *2* | *1* | *2* | *1* | *2* | *1* | *2* | *1* | *2* | *1* | *2* | *1* | *2* |
| SO | 2 | 1 | 1 | 3 | 2 | 3 | 2 | 4 | 3 | 1 | 4 | 1 | 1 | 3 |
| WO | 1 | 2 | 4 | 1 | 4 | 1 | 4 | 1 | 1 | 4 | 1 | 3 | 3 | 2 |
| ST | 3 | 3 | 2 | 4 | 3 | 2 | 3 | 2 | 2 | 3 | 2 | 4 | 4 | 1 |
| WT | 4 | 4 | 3 | 2 | 1 | 4 | 1 | 3 | 4 | 2 | 3 | 2 | 2 | 4 |
| Sub-criteria | Global | | O1 | | O2 | | O3 | | O4 | | O5 | | O6 | |
| *Set* | *1* | *2* | *1* | *2* | *1* | *2* | *1* | *2* | *1* | *2* | *1* | *2* | *1* | *2* |
| SO | 2 | 1 | 4 | 4 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| WO | 1 | 2 | 2 | 2 | 1 | 1 | 3 | 4 | 3 | 2 | 4 | 4 | 2 | 3 |
| ST | 3 | 3 | 1 | 1 | 3 | 3 | 2 | 2 | 2 | 3 | 1 | 2 | 4 | 4 |
| WT | 4 | 4 | 3 | 3 | 4 | 4 | 4 | 3 | 4 | 4 | 3 | 3 | 3 | 2 |
| Sub-criteria | Global | | T1 | | T2 | | T3 | | T4 | | T5 | | T6 | |
| *Set* | *1* | *2* | *1* | *2* | *1* | *2* | *1* | *2* | *1* | *2* | *1* | *2* | *1* | *2* |
| SO | 2 | 1 | 3 | 1 | 1 | 3 | 1 | 4 | 1 | 3 | 3 | 1 | 1 | 2 |
| WO | 1 | 2 | 1 | 4 | 3 | 4 | 3 | 3 | 4 | 1 | 2 | 3 | 2 | 4 |
| ST | 3 | 3 | 4 | 2 | 4 | 1 | 4 | 1 | 3 | 2 | 1 | 4 | 4 | 1 |
| WT | 4 | 4 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 4 | 4 | 2 | 3 | 3 |

Table 10
Percentage difference of the averaged weights of sub-criteria of each SWOT category and comparison between different analyses

| Sub-criteria | AHP | ANP | % | FAHP | FANP | % | AHP/FAHP ANP/FANP | TOPSIS/ FTOPSIS | % |
|---|---|---|---|---|---|---|---|---|---|
| S | 0.059 | 0.057 | -4.3% | 0.061 | 0.070 | 14.4% | 0.060 | 0.037 | -38.3% |
| W | 0.031 | 0.032 | 4.2% | 0.031 | 0.022 | -28.5% | 0.031 | 0.046 | 48.4% |
| O | 0.058 | 0.055 | -4.6% | 0.056 | 0.063 | 11.0% | 0.057 | 0.026 | -54.4% |
| T | 0.018 | 0.022 | 21.2% | 0.018 | 0.012 | -34.5% | 0.018 | 0.058 | 222.2% |


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