Fuzzy AHP-TOPSIS Strategic Theme Selection and Application

Ali Üsküdar, Yavuz Selim Özdemir
Istanbul Arel University/Department of Industrial Engineering, Istanbul, Turkey
Email: {draliuskudar@gmail.com, yavuzselimozdemir@arel.edu.tr}

Özgür Karabüber, Ersin Yıldırım and Özgür Gezer
IETT Transport Planning Division/1&2 European Regional Transportation Planning, IETT Information Technology, IT/Server and Network Systems. SMC Turkey Automation/Technical Support Engineering, Istanbul, Turkey
Email: {ozgur.karabuber@iett.gov.tr, ersin.yildirim@iett.gov.tr, ozgurgezer547@gmail.com}

Abstract—Today, many private or corporate companies have to make strategic decisions on various issues. The purpose of these decisions is to achieve either maximum efficiency or profit. In this context, two topics are especially emphasized. One is the balanced scorecard (BSC) method and the other is the multi-criteria group decision-making. The purpose of our work is to determine the themes to be established during the strategy selection process of the IETT (Istanbul Electric Tram and Tunnel) Management Company, which operates in the state-owned and public transportation sector, whose criteria are determined by the institutional report method, employing fuzzy AHP and fuzzy TOPSIS method.

Index Terms—fuzzy AHP; fuzzy TOPSIS; balanced scorecard

I. INTRODUCTION

In recent years, it has been understood how strategic management is important in not only profit-oriented private companies but also non-profit public institutions. In the strategic decision-making and planning stages, Kaplan and Norton's balanced scorecard method is used by many private companies. Initially the focus and practice of balanced scorecard is directed towards the private sector (profit-making institutions), but it also provides an excellent opportunity for the development of management in state-owned and non-profit-making institutions [1].

Balanced scorecard method examines four different dimensions in order to measure the extent to which the needs are met effectively and efficiently. These are financial dimension, customer dimension, inner process dimension, learning and innovation dimensions. Accordingly, the financial dimension [2] demonstrates whether financial performance indicators contribute to the growth of the company's strategy, practices and management's profitability. The customer dimension [3] assesses the quality of the products produced by the company at the customer's point of view. The quality of services is measured by using indicators such as error rate, rate of service fulfillment on time. The internal process dimension [3] examines what arrangements should be made within the company to meet customer expectations in a customer-focused management system. In the public sector, as in the private sector, small or large institutions have dissimilar business processes. Balanced scorecard method makes it possible to measure the results of these business processes and to select the best alternative that enables the achievement of the corporate mission and the improvement of the results. The dimension of learning and innovation [4] attaches importance to innovating the institution in order to provide the best service to the beneficiaries of the service in the public sector as it is in the private one. Thus, it is necessary to increase the skills and motivation of the employees in order to fulfill the corporate objectives. Considering these four dimensions, necessary criteria can be established in private and public institutions.

AHP (Analytic Hierarchy Processes) and TOPSIS (Technique for Order Preference Similarity to Ideal Solution) methods can be applied to many areas where criteria are set. The AHP and TOPSIS methods are based on the determination of the weights of integer scores obtained from a group of decision-makers after they have been processed through a series of calculations.

Integers are employed in classical AHP and TOPSIS methods. But people's predictions may not be expressed exactly by integer scores. In this context, fuzzy sets are used in order to make the predicted linguistic expressions more understandable and produce more reliable results.

The theory of fuzzy sets was first introduced to the literature by Zadeh [5] in 1965 and developed rapidly being used in many researches. The first fuzzy AHP study by Laarhoven and Pedrycz (1983) [6] compared the fuzzy rates defined by trapezoidal membership functions. Buckley (1985) [7] determined the fuzzy priorities of the
comparison ratios by the trapezoidal membership function. The first fuzzy TOPSIS study was created by Chen (2000) [8] as extensions of the TOPSIS method via a system-analysis-engineer hiring process of group decision-making of software company in a fuzzy environment.

II. Fuzzy Set Theory

**Definition 1:** A fuzzy set \( \tilde{n} \) in a universe of discourse \( X \) is characterized by a membership function \( \mu_\tilde{n}(x) \) which associates with each element \( x \) in \( X \) a real number in the interval \([0,1]\). The function value \( \mu_\tilde{n}(x) \) is termed the grade of membership of \( x \) in \( \tilde{n} \) [9].

**Definition 2:** A fuzzy set \( \tilde{n} \) in the universe of discourse \( X \) is convex if and only if
\[
\mu_\tilde{n}(\lambda x_1 + (1-\lambda)x_2) \geq \min\{\mu_\tilde{n}(x_1), \mu_\tilde{n}(x_2)\}. \tag{1}
\]
For all \( x_1, x_2 \) in \( X \) and all \( \lambda \in [0,1] \), where \( \min \) denotes the minimum operator [10].

**Definition 3:** The height of a fuzzy set is the largest membership grade attained by any element in that set. A fuzzy set \( \tilde{n} \) in the universe of discourse \( X \) is called normalized when the height of \( \tilde{n} \) is equal to 1 [10].

**Definition 4:** A fuzzy number is a fuzzy subset in the universe of discourse \( X \) that is both convex and normal [9].

**Definition 5:** The \( \alpha \)-cut of fuzzy number \( \tilde{n} \) is defined as \( \tilde{n}^\alpha = \{x: \mu_\tilde{n}(x) \geq \alpha, x \in X\} \).

Where \( \alpha \in [0,1] \).

The symbol \( \tilde{n}^\alpha \) represents a non-empty bounded interval contained in \( X \), which can be denoted by \( \tilde{n} = [\tilde{n}_l, \tilde{n}_u] \), \( \tilde{n}_l \) and \( \tilde{n}_u \) are the lower and upper bounds of the closed interval, respectively [9,11]. For a fuzzy number \( \tilde{n} \), if \( \tilde{n}_l > 0 \) and \( \tilde{n}_u \leq 1 \) for all \( \alpha \in [0,1] \), then \( \tilde{n} \) is called a standardized (normalized) positive fuzzy number [12].

**Definition 6:** Positive trapezoidal fuzzy number (PTFN) \( \tilde{n} \) can be defined as \( (n_1, n_2, n_3, n_4) \). The membership function \( \mu_\tilde{n}(x) \) is defined as [9].
\[
\mu_\tilde{n}(x) = \begin{cases} 
0, & x < n_1, \\
\frac{x-n_3}{n_2-n_3}, & n_1 \leq x \leq n_2, \\
\frac{x-n_4}{n_3-n_4}, & n_3 \leq x \leq n_4, \\
0, & x > n_4.
\end{cases} \tag{3}
\]

For a trapezoidal fuzzy number \( \tilde{n} = (n_1, n_2, n_3, n_4) \) if \( n_2 = n_3 \), then \( \tilde{n} \) is called a triangular fuzzy number. A non-fuzzy number \( r \) can be expressed as \((r,r,r,r)\). By the extension principle [13], the fuzzy sum \( \oplus \) and fuzzy subtraction \( \ominus \) of any two trapezoidal fuzzy numbers are also trapezoidal fuzzy numbers; but the multiplication \( \otimes \) of any two trapezoidal fuzzy numbers is only an approximate trapezoidal fuzzy number. Given any two-positive trapezoidal fuzzy numbers, \( \tilde{m} = (m_1, m_2, m_3, m_4), \tilde{n} = (n_1, n_2, n_3, n_4) \) and a positive real number \( r \), some main operations of fuzzy numbers \( \tilde{m} \) and \( \tilde{n} \) can be expressed as follows:
\[
\tilde{m} \oplus \tilde{n} = [m_1 + n_1, m_2 + n_2, m_3 + n_3, m_4 + n_4], \tag{4}
\]
\[
\tilde{m} \ominus \tilde{n} = [m_1 - n_4, m_2 - n_3, m_3 - n_2, m_4 + n_1]. \tag{5}
\]
\[
\tilde{m} \otimes \tilde{n} = [m_1 r, m_2 r, m_3 r, m_4 r]. \tag{6}
\]
\[
\tilde{m} \oslash \tilde{n} \equiv [m_1 n_1, m_2 n_2, m_3 n_3, m_4 n_4]. \tag{7}
\]

**Definition 7:** A linguistic variable is a variable whose values are expressed in linguistic terms [11]. Fuzzy numbers can also represent these linguistic values.

Let \( \tilde{m} = (m_1, m_2, m_3, m_4) \) and \( \tilde{n} = (n_1, n_2, n_3, n_4) \) be two trapezoidal fuzzy numbers. Then the distance between them can be calculated by using the vertex method as [8].
\[
d_r(\tilde{m}, \tilde{n}) = \sqrt{\frac{1}{4}[(\tilde{m}_1 - \tilde{n}_1)^2 + (\tilde{m}_2 - \tilde{n}_2)^2 + (\tilde{m}_3 - \tilde{n}_3)^2 + (\tilde{m}_4 - \tilde{n}_4)^2]} \tag{8}
\]

**III. Fuzzy AHP-TOPSIS Hybrid Model**

The steps of the fuzzy AHP-TOPSIS hybrid method are as follows:

X: Set of alternatives
F: Set of criteria
\( X = \{x_1, x_2, \ldots, x_n\} \)
\( F = \{f_1, f_2, \ldots, f_k\} \)
Assuming \( k \) amount of decision makers. \( \{D_1, D_2, \ldots, D_k\} \)

The set of criterion, \( F \), is divided into two separate sets as \( F_1 \) and \( F_2 \). \( F_1 \) represents a set of benefit criteria, \( F_2 \) represents a set of cost criteria. In this case: \( F_1 \cap F_2 = \emptyset \)

**Step 1:** Pairwise comparison matrices for criteria, subcriteria and alternatives are constructed using linguistic terms. Each element \( \tilde{a}_{ij}^k \) of the pairwise comparison matrix \( A_k \) is a fuzzy number corresponding to its linguistic term. The pairwise comparison matrix is given by [7];
\[
\tilde{A}_p = \begin{bmatrix} 1 & \tilde{a}_{12}^k & \ldots & \tilde{a}_{1n}^k \\
\tilde{a}_{21} & 1 & \ldots & \tilde{a}_{2n}^k \\
\vdots & \vdots & \ddots & \vdots \\
\tilde{a}_{n1}^k & \tilde{a}_{n2} & \ldots & 1 \end{bmatrix} = \begin{bmatrix} 1 & \tilde{a}_{12} & \ldots & \tilde{a}_{1n} \\
\tilde{a}_{21} & 1 & \ldots & \tilde{a}_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
\tilde{a}_{n1} & \tilde{a}_{n2} & \ldots & 1 \end{bmatrix} \quad (9)
\]

\( A_k = (\tilde{a}_{ij})_{nxn} \).

**TABLE I. Definition and Intervals Fuzzy Scales of the Linguistic Variable (G.J.Zhang et al.2012)**

<table>
<thead>
<tr>
<th>Trapezoidal Interval Type-1 Fuzzy Scales.</th>
<th>Equally important (E)</th>
<th>Weakly important (W)</th>
<th>Essentially important (ES)</th>
<th>Very strongly important (VS)</th>
<th>Absolutely important (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1,1,1)</td>
<td>(2,5/2,7/2,4)</td>
<td>(4,9/2,11/2,6)</td>
<td>(6,13/2,15/2,8)</td>
<td>(8,17/2,9,9)</td>
</tr>
</tbody>
</table>

The geometric mean of \( k \) fuzzy set is calculated as follows:
\[
\tilde{A} = \left( \tilde{a}_{ij}^1 \otimes \tilde{a}_{ij}^2 \otimes \ldots \otimes \tilde{a}_{ij}^k \right)^{1/p} = \sqrt[p]{\tilde{a}_{ij}^1 \otimes \tilde{a}_{ij}^2 \otimes \ldots \otimes \tilde{a}_{ij}^k} \tag{10}
\]
For the evaluation procedure, the linguistic terms given in Table I are used.

Step 2: The geometric mean of each line is calculated and then the normalization process is applied on the fuzzy weights. The geometric mean of each line is calculated as follows [7]:

\[
\widetilde{\bar{r}}_i = \left( \tilde{a}_{i1} \otimes \tilde{a}_{i2} \ldots \otimes \tilde{a}_{in} \right)^{1/n}
\]

Here, \(\tilde{a}_{in}\) is the linguistic evaluation of the criterion compared to the n. criterion, \(\tilde{r}_i\) the geometric mean value that is calculated by comparing the measure with all the criteria.

Step 3: Calculation of global weights for each sub criterion;

\[
\tilde{w}_{ij} = \tilde{w}_{ij1} \otimes \tilde{w}_i, \quad 1 \leq i \leq m, \text{ and } 1 \leq j \leq n.
\]

Step 4: For p. decision maker, a decision matrix of \(Y_p\) and mean decision matrix \(\bar{Y}\) are created [14].

\[
Y_p = \left( \left( \tilde{f}_{ij} \right)_{m \times n} \right) = \left( \begin{array}{cccc}
\tilde{f}_{p11} & \tilde{f}_{p12} & \ldots & \tilde{f}_{p1n} \\
\tilde{f}_{p21} & \tilde{f}_{p22} & \ldots & \tilde{f}_{p2n} \\
\vdots & \vdots & \ddots & \vdots \\
\tilde{f}_{pm1} & \tilde{f}_{pm2} & \ldots & \tilde{f}_{pmn} \\
\end{array} \right)
\]

Step 5: A weighted decision matrix

\[
\bar{F}_w = \left( \left( \tilde{v}_{ij} \right)_{m \times n} \right) = \left( \begin{array}{cccc}
\tilde{v}_{11} & \tilde{v}_{12} & \ldots & \tilde{v}_{1n} \\
\tilde{v}_{21} & \tilde{v}_{22} & \ldots & \tilde{v}_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
\tilde{v}_{m1} & \tilde{v}_{m2} & \ldots & \tilde{v}_{mn} \\
\end{array} \right)
\]

Step 6: The fuzzy positive-ideal solution (FPIS, \(A^*\)) and the fuzzy negative-ideal solution (FNIS, \(A^-\)) are defined as [15]:

\[
A^* = \left( \tilde{v}_{11}, \tilde{v}_{12}, \ldots, \tilde{v}_{1n} \right), A^- = \left( \tilde{v}_{11}, \tilde{v}_{12}, \ldots, \tilde{v}_{1n} \right)
\]

Step 7: The closeness coefficient is determined [15].

\[
CC_i = \frac{d_i^-}{d_i^- + d_i^+}
\]

Step 8: Alternatives are ranked in decreasing order. The larger the value of \(CC_i\), the higher the preference of the alternative [15].

### IV. Numerical Examples

In this section, examples are presented demonstrating the decision-making process of the fuzzy multi-feature set of the proposed method.

Alternatives are strategically selected by the IETT’s expert staff, taking into consideration of the annual, 5-year and 10-year development plans and following the latest trends and investments in the world population, based on the previous knowledge, experience, and strategies of the IETT. The experts in this field constitute the directors of the departments designated by the relevant authorities. In this context, 7 decision makers and 12 alternatives are foreseen.

IETT refers to Kaplan and Norton’s Balanced Scorecard Method. The main and sub-criteria were selected by expert staff by analyzing the consistency with each other in accordance with the institutional report method.

Accordingly, 12 sub-criteria were selected as the most appropriate for the 4 main criteria and institution specified in the Balanced Scorecard.

Efficient Processes (a1), "Leadership and Communication" (a2), "Holistic Leadership" (a3), "Agility in Service" (a4), "Strong Financial Structure" (a5), "Sustainable Services" (a6), Mankind-Environment-Profit (a7), "Business and Passenger Safety" (a8), "Road and passenger safety" (a9), "Cost" (a10), "Income" (a11), "Financial Sustainability" (a12), "Quality" (a13), "Productivity" (a14), "Activity" (a15), "Employee Qualification" (a16), "Information System Competency" (a17), "Motivation Authorization and Adaptation" (a18).

Consistency ratios are calculated based on the data obtained through questionnaires of each decision maker, by creating binary comparison matrices as in Table III and by being dependent on previously given linguistic terms. In our numerical example, all decision tables are consistent. Consistency ratios are less than 0.1.

Step 1: Table III shows the binary comparison matrices between the main criterion and the sub criteria in the hierarchical system.

### Table III. The Binary Comparison Matrix of the Main Criteria and Sub-Criteria for the D1 Decision Maker

<table>
<thead>
<tr>
<th>Main and Sub-criterion comparison matrix</th>
<th>Main Criterion Matrix</th>
<th>Sub-criteria Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>k1</td>
<td>k2</td>
</tr>
<tr>
<td>k1 E</td>
<td>ES</td>
<td>VS</td>
</tr>
<tr>
<td>k2 1/ES</td>
<td>W</td>
<td>E</td>
</tr>
<tr>
<td>k3 1/VS</td>
<td>1/W</td>
<td></td>
</tr>
<tr>
<td>k4 1/ES</td>
<td>W</td>
<td>E</td>
</tr>
</tbody>
</table>

Table IV shows the calculation of the decision matrix by taking the geometric mean of the binary comparison matrices of the main criterion and the sub criteria obtained from the evaluation of the relevant decision makers.

### Table IV. The Binary Comparison of Geometric Mean Decision Matrices

<table>
<thead>
<tr>
<th>Main Criterion Matrix</th>
<th>Sub-criteria Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>k1 (1.00,1.00,1.00)</td>
<td>(5.48,4.01,5.05,5.57)</td>
</tr>
<tr>
<td>k2 (0.18,0.20,0.25,0.29)</td>
<td>(1.00,1.00,1.00)</td>
</tr>
<tr>
<td>k3 (0.17,0.18,0.20,0.21)</td>
<td>(0.34,0.37,0.47,0.54)</td>
</tr>
<tr>
<td>k4 (0.14,0.14,0.17,0.18)</td>
<td>(0.33,0.37,0.46,0.52)</td>
</tr>
<tr>
<td>k5 (4.76,5.10,5.67,5.90)</td>
<td>(5.47,6.04,6.96,7.31)</td>
</tr>
<tr>
<td>k6 (1.84,2.12,2.67,2.97)</td>
<td>(1.92,2.20,2.74,3.02)</td>
</tr>
<tr>
<td>k7 (1.00,1.00,1.00,1.00)</td>
<td>(1.22,1.41,1.79,2.00)</td>
</tr>
<tr>
<td>k8 (0.50,0.56,0.71,0.82)</td>
<td>(1.00,1.00,1.00,1.00)</td>
</tr>
</tbody>
</table>

### Table V. Normalized of Main Criteria

<table>
<thead>
<tr>
<th>Main Criterion Matrix</th>
<th>Normalized Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>k1 (0.48,0.55,0.71,0.81)</td>
<td>(0.90,1.00,1.00,1.00)</td>
</tr>
<tr>
<td>k2 (0.14,0.16,0.22,0.26)</td>
<td>(0.34,0.37,0.47,0.54)</td>
</tr>
<tr>
<td>k3 (0.08,0.09,0.12,0.14)</td>
<td>(0.22,0.27,0.33,0.37)</td>
</tr>
<tr>
<td>k4 (0.06,0.07,0.09,0.11)</td>
<td>(0.12,0.14,0.17,0.20)</td>
</tr>
</tbody>
</table>

Step 2: Employing Table IV and Equation 11, the geometric mean of each line is calculated as shown in Table VI.

### Table VI. Global Weight of Sub-Criteria

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Alternatives</th>
<th>Decision-Makers</th>
</tr>
</thead>
<tbody>
<tr>
<td>k1</td>
<td>A1</td>
<td>VH</td>
</tr>
<tr>
<td></td>
<td>A2</td>
<td>M L H</td>
</tr>
<tr>
<td></td>
<td>A3</td>
<td>M L H</td>
</tr>
<tr>
<td></td>
<td>A4</td>
<td>L M H</td>
</tr>
<tr>
<td></td>
<td>A5</td>
<td>M L H</td>
</tr>
<tr>
<td></td>
<td>A6</td>
<td>M L H</td>
</tr>
<tr>
<td></td>
<td>A7</td>
<td>M V L</td>
</tr>
<tr>
<td></td>
<td>A8</td>
<td>M L M</td>
</tr>
<tr>
<td></td>
<td>A9</td>
<td>M H M</td>
</tr>
<tr>
<td></td>
<td>A10</td>
<td>M L M</td>
</tr>
<tr>
<td></td>
<td>A11</td>
<td>H H H</td>
</tr>
<tr>
<td></td>
<td>A12</td>
<td>VH</td>
</tr>
</tbody>
</table>

Step 3: Employing Table V and Equation 13, the global weight is calculated as shown in Table VII and Equation 14 and 15. Decision matrices are denoted by $Y_1, Y_2, Y_3, Y_4, Y_5, Y_6$ and $Y_7$, alternatives by $a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8, a_9, a_{10}, a_{11}$ and $a_{12}$. $Y$ is the average decision matrix.

Based on the Equation 15, the mean decision matrix $\bar{Y}$ can be constructed. It is calculated as follows:

$$\bar{Y}_{11} = (0.90, 1.00, 1.00, 1.00).$$
\[ f_{112} = (0.79, 0.93, 0.93, 0.99) \]

**Step 5:** Based on Equation 16 and 17, a weighted decision matrix \( f_{w} \) is constructed. It is demonstrated as follows:

\[ \overline{\theta}_{11} = (0.18, 0.27, 0.46, 0.60) \]

\[ \overline{\theta}_{112} = (0.16, 0.25, 0.43, 0.59) \]

**Step 6:** Based on Equation 18, 19 and 20, the fuzzy positive-ideal solution (FPISA) and the fuzzy negative-ideal solution (FNISA) are defined as:

\[ d_{i}^{+}(a_{j}) = 0.64 \quad d_{i}^{-}(a_{j}) = 0.41 \]

\[ A^{+} = (11.05, 11.25, 11.27, 11.40, 11.51, 11.46, 11.26, 11.38, 11.20, 11.30, 11.18, 11.17) \]

\[ A^{-} = (1.09, 0.89, 0.87, 0.72, 0.60, 0.65, 0.68, 0.74, 0.94, 0.84, 0.97, 0.97) \]

**Step 7:** Using the Equation 21, the proximity coefficient \( C(a_j) \) of \( a_j \) is calculated.

Here, \( 1 \leq j \leq 12 \).

\[ C(a_{1}) = 0.0898, \quad C(a_{2}) = 0.0729, \quad C(a_{3}) = 0.0713, \]
\[ C(a_{4}) = 0.0594, \quad C(a_{5}) = 0.0495, \quad C(a_{6}) = 0.0535, \]
\[ C(a_{7}) = 0.0727, \quad C(a_{8}) = 0.0608, \quad C(a_{9}) = 0.0778, \]
\[ C(a_{10}) = 0.0693, \quad C(a_{11}) = 0.0796, \quad C(a_{12}) = 0.0798 \]

**Step 8:** The result is as follows the result is as follows

\[ C(a_{1}) > C(a_{12}) > C(a_{11}) > C(a_{9}) > C(a_{4}) > C(a_{7}) > C(a_{2}) > C(a_{10}) > C(a_{8}) > C(a_{5}) > C(a_{6}) > C(a_{3}) \]

According to the results, Quality of Service is the most important theme for transportation. After that, Road and passenger safety, Business and Passenger Safety, Sustainable Services comes respectively. The results show that, Quality a Road and passenger safety, Business and Passenger Safety, Sustainable Services and Safety comes first for public transportation. On the other hand, Sustainability is the important and popular theme in Metropol public transportation services.

V. CONCLUSION

This study aimed to determine the selection of the themes which are included in the 5-year development plans and which are intended to be invested, by using multi-criteria decision-making method, with reference to Balanced Scorecard-BSC used in IETT. A hybrid approach based on AHP and TOPSIS methods has been used in fuzzy environment. In our study, the scale for regulating the appropriate criteria in the theme selection was determined by the balanced scorecard method proposed by the literature. Balanced Scorecard Method (BSC) for main and sub-criteria, the FAHP method is used to determine the importance of the main criteria and sub-criteria, and the FTOPSIS method is used to rank the themes to be invested. The most important feature distinguishing this study is that this method has not been utilized before in the strategic decision-making stage of any transportation company. This method has been proposed as an approach in which decision makers’ preferences are better modeled since the data received from each decision-maker is evaluated as a linguistic term. The data were obtained by questionnaires applied to expert decision makers who have authority and knowledge. The selection of the themes to be invested in IETT is carried out within a strategic framework by the SWOT analysis, taking into account the opinions of the expert decision makers. This study targets that the consistency between the data obtained from the expert decision makers is audited and the leader determines the themes to be invested and contributes to the strategic and scientific decisions of the leader.

REFERENCES


Ali Üsküdar was born in Istanbul, Turkey in 1985. He received his Associate’s degree from Istanbul University, Industrial Electronic, Istanbul, Turkey in 2006. He received his B.S. degree from Anadolu University, Public Administration, Eskisehir, Turkey in 2014. Also he received the B.S. degree from Istanbul University, Industrial Engineering, Istanbul, Turkey in 2017 and M.S. degree from Engineering Management, Istanbul Arel University, Istanbul, Turkey in 2017, respectively. Between 2006 and 2017, he worked at Automation and Robotic Technologies R&D department in Umar Machinery, industry and trade company. In 2017, after living in London for 6 months, he came back to his country to proceed his academic education. He has been taking part in
various academic studies with support of Istanbul Arel University since then.

Yavuz Selim Özdemir was born in Ankara, Turkey in 1981. He received the B.S. degree from Baskent University, Industrial Engineering Department, Ankara, Turkey in 2004 and M.S. degree in Computer Engineering from Baskent University in 2008, respectively. In 2013, he received his Ph.D. in Modelling and Design of Engineering Systems from Atılım University. His research interests are Multi Criteria Decision Making, Fuzzy Logic, Intellectual Capital and Heuristic Optimization.

Assist. Prof. Dr. Özdemir is currently working as Vice Chair at Department of Industrial Engineering in Istanbul Arel University.