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The Effective Personnel Selection Via Multi-criteria Decision-making Method Analytic Hierarchy Process (AHP): A Web-based Application

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Abstract

Decision-making is a process that people encounter in their daily or business lives. The process aims at reaching a conclusion depending on the aims of the people. Multiple factors affect the process of decision-making depending on the characteristics of these factors. These factors that affect the process of decision-making complicate encountered problems, and in this stage as a solution, multi-criteria decision-making methods are preferred to use by the decision-makers. Decision-making methods are categorized according to specific goals served to give the best results to decision-makers. Certainly, the most important goal for organizations is to ensure that the right person works in the right job in line with his/her goals. The problems that are encountered by human resources managers is decision-making problems. A small mistake made by human resource department during the personnel selection can cause negative consequences in short or long term for companies. In this study, a web-based application was developed in order to solve the personnel-selection problems of human resources management. A model that is based on multi-criteria selection has been developed to ensure the elimination of candidates through the program based on solution algorithm of Analytic Hierarchy Process (AHP), which is one of the most widely used decision-making methods designed as a web-based application so far.

Keywords: multi-criteria decision-making, analytic hierarchy process, human resources management, personnel selection, web-based application

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1. Introduction

Peoples have to make a decision one way or the other throughout their lives. Decision-making includes personal and general issue in their lives. Depending on personal, social and environmental needs are a result of this action. For instance, the choice of what to eat daily for a person, the choice of where to go for an annual leave,

etc. In similar cases, there are many factors and options arise for making decision process. The presence of many factors and options leads to multi-criteria decision-making problems.

As known, making a decision is a vital for organization and their functions of management. The organizations aims to have got a good personnel on right work. Therefore, the organizations have to make a decision step by step at their decision process. Certainly, the most important of these steps is choice (selection) of personnel for right team. Selecting personnel is a complex form and difficult process for human resources management. With the rapid development of requirement, there are a large number of criteria and alternatives in human resources management. Chen, Zhang and Lv focused on the problem of human resource management mode selection based on analytic hierarchy process and they propose a human resources selection study based on ahp, which is a multi-criteria decision-making calculating method with quantitative and quality assessments and prioritization of alternatives [1]. The problems that is encountered by human resources managers is called a decision-making problems. A small mistake is made by human resource department during the personnel selection, can cause negative consequences in short or long-term for companies. In the election process, decision-makers consider more than one criterion and select candidates according to these constraints (criteria). to support the existing staff selection process by making use of developing technological and scientific methods and to make the process easier. It is necessary to make the best selection or ranking among the multiple objectives in the decision-making process and among the conflicting options. In this stage, decision-makers support very specific decision-making methods. One of the most important problems faced by human resources management is the need for a systematic approach to reaching the best solution in the problem of personnel selection. In this sense, it is desirable to develop a model for the decision-making process of the staff selection process. It is another purpose of the study to determine the basic criteria that are effective in the selection process, to determine and evaluate the effects of the criteria on the alternatives and to make it an application using the Analytical Hierarchy Process (AHP).

Liu et al. researched efficiency of wind turbine for some criteria such as profitability, power characteristics, equipment reliability, equipment consumption, and wind characteristics. AHP method is used to determine criteria weight values and also and the energy efficiency level of wind turbines were evaluated via comprehensive fuzzy evaluation [2] Sennaroglu and Celebi research that location select problem via multiple criteria. They used AHP, Promethee and V*i*kor method to solve problem. Weights of

criteria are determined by AHP. Then ranking and selection processes of four alternatives are carried out using PROMETHEE and VIKOR methods [3]. Silas and Rajsingh research health service conditions and selection process for the right person right hospital. They compared results between electre, promethee and AHP. Finally they reached that promethee is the best solution for this problem [4]. At the same time, selection of personnel [5], selection of production equipment to increase production capacity, to develop, to keep up with technology, to shape according to customer's desires and selection of academician for military school [6] studies are available. The studies conducted in this area have used the criteria of multi-criteria decision-making on the aims such as customer satisfaction, low cost and best service in consideration of today's competitive environment conditions. In 2013, Cakir and Percin researched on the performance measurement of the best selected logistics companies under certain conditions in the performance measurement of logistics companies [7].

This study focused to develop decision-making process. A model for personnel selection process of human resources management in the study was developed and web-based by applying multi-criteria AHP method steps. Developed for the personnel selection process, this application includes an interface where people can fill out and save the application form, decision-making area for decision-makers, levels of importance for these inland criteria, and criteria for selection. After the choices in the decision area, the AHP algorithm is running, the screen is the people to be compared and the most suitable person. The PHP programming language is used for this and the MySQL database is provided to show these results.

2. Methods

2.1. Analytic hierarchy process (AHP)

Analytic Hierarchy Process (AHP) is one of multi criteria decision-making methods introduced by Thomas L. Saaty in 1977 [8]. AHP is a quantitative method in which alternatives are sorted and selected according to certain criteria in decision-making process [9]. AHP provides to convert subjective values into relative values [10]. AHP is a very important tool for the communication and understanding of information, with a multi-criteria evaluation theory that can use quantitative and qualitative data in combination, explanatory, scoring and scaling through binary comparisons [11]. By reducing complex decisions to a series of pairwise comparisons, and then synthesizing

the results, the AHP helps to capture both subjective and objective aspects of a decision [12].

The AHP generates a weight for each evaluation criterion according to the decision-makers pairwise comparisons of the criteria. Evaluating a quantitative as well as qualitative criteria and alternatives is the most important strength of AHP method [13]. The higher the weight, the more important the corresponding criterion. Next, for a fixed criterion, the AHP assigns a score to each option according to the decision-makers pairwise comparisons of the options based on that criterion. The higher the score, the better the performance of the option with respect to the considered criterion. Finally, the AHP combines the criteria weights and the options scores, thus determining a global score for each option, and a consequent ranking.

When make a comparisons, the following scaling table is used [12]. The fundamental scale table is shown as follows [14].

Table 1: The fundamental scale.

Intensity of importance on an absolute scale	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective.
3	Moderate importance of one over another	Experience and judgement strongly favor one activity over another
5	Essential or strong importance	Experience and judgement strongly favor one activity over another
7	Very strong importance	An activity is strongly favored and its dominance demonstrated in practice
9	Intermediate values between the two adjacent judgments	The evidence favoring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8		When compromise is needed
Reciprocals	If activity *i* has one of the above numbers assigned to it when compared with activity *j*. then *j* has the reciprocal value when compared with *i*.	
Rationales	Ratios arising from the scale	If consistency were to be forced by obtaining *n* numerical values to span the matrix.

Source: Saaty, 1990.

2.1.1. Steps to AHP methods

The solution of the AHP method takes place in the following steps [15].

Step 1: First, decision points (alternatives) and secondly factors (criteria) that affect decision points are determined. One of the most important features of the AHP is that

it divides the decision problem into elements that are in a hierarchical relationship. Criteria is in the middle level and alternatives is in the down level [16].

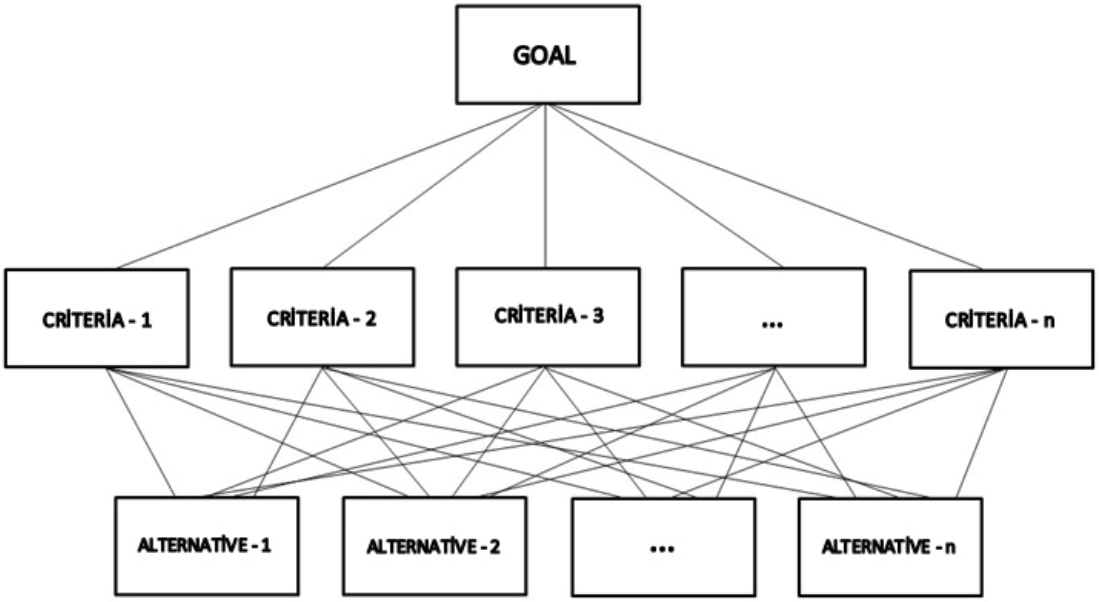

Figure 1: AHP Hierarchy. **Source:** Created by the author.

Step 2: The criterion comparison matrix is constructed. Binary comparison matrix means that criteria and factors are compared with each other. Binary comparative matrix was developed in order to determine the priority distributions of the criteria. The comparison matrix is shown as follows.

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}$$

This matrix takes on the value of 1 when the matrix components on the diagonal, i = j. Comparisons of criteria are made according to the importance values they have according to each other. If the first criterion for the comparator is more important than the third criterion, then the first row of the matrix takes the third column component

(i = 1, j = 3), 3. In the opposite case, because of the AHP's reciprocal theorem, the third criterion takes on the value of significance 1/3 according to the first criterion.

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & a_{22} & \cdots & a_{2n} \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ 1/a_{1n} & & \cdots & a_{nn} \end{bmatrix}$$

For the components below the diagonal, the following formula is used.

$$a_{ji} = \frac{1}{a_{ij}} \tag{1}$$

Step 3: The percentages of significance are determined for the criteria. the column vectors that make up the comparison matrix are used. B column vector is created. B column vector is calculated by the normalization method [17]. The following formulas are used for these operations.

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

$$B_i = \begin{bmatrix} b_{11} \\ b_{21} \\ . \\ . \\ . \\ b_{n1} \end{bmatrix}$$

The steps described are repeated for each criterion. When the B column vectors are combined, the C matrix will be generated.

$$C = \begin{bmatrix} c_{11} & c_{12} & \cdots & c_{1n} \\ c_{21} & c_{22} & \cdots & c_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ c_{n1} & c_{n2} & \cdots & c_{nn} \end{bmatrix}$$

The arithmetic mean of the sequence components forming the matrix C is obtained and the column vector W, called the priority vector, is obtained.

$$w_i = \frac{\sum_{j=1}^{n} c_{ij}}{n} \tag{3}$$

$$W = \begin{bmatrix} w_1 \\ w_2 \\ . \\ . \\ w_n \end{bmatrix}$$

Step 4: The consistency of comparisons made for the criterion is measured. The resultant consistency ratio (CR/Consistency Ratio) is used to assess the consistency of the comparison of the priority vectors and therefore the individual differences between the criteria. CR calculation is based on comparison of criterion and λ. When λ is calculated, the matrix A is multiplied by the vector W and the column vector D is found. It is shown as follows.

$$D = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} x \begin{bmatrix} w_1 \\ w_2 \\ . \\ . \\ . \\ w_n \end{bmatrix}$$

Then the base value is 'E'. he arithmetic mean of these values gives the base value (λ) for comparison.

$$E_i = \frac{d_i}{w_i} \quad (i = 1, 2, \ldots, n) \tag{4}$$

$$\lambda = \frac{\sum_{i=1}^{n} E_i}{n} \tag{5}$$

After λ has been calculated, the Consistency Indicator (CI) for the consistency ratio CR is calculated. In the last stage, the CI is divided by the standard correction value called the Random Indicator (RI) to obtain the Consistency Ratio (CR).

$$CI = \frac{\lambda - n}{n - 1} \tag{6}$$

$$CR = \frac{CI}{RI} \tag{7}$$

Step 5: For each criterion, the percentage significance distributions at the 'm' decision point are calculated. S column vectors representing the percent distributions according to the decision points of the criterion are obtained. This vector is shown as follows.

$$S_i = \begin{bmatrix} S_{11} \\ S_{21} \\ . \\ . \\ . \\ S_{m1} \end{bmatrix}$$

Step 6: The result distributions at decision points are calculated. In this stage, an mxn dimensional K decision matrix is formed. This matrix is shown as follows.

$$K = \begin{bmatrix} S_{11} & S_{12} & \cdots & S_{1n} \\ S_{21} & S_{22} & \cdots & S_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ S_{m1} & S_{m2} & \cdots & S_{mn} \end{bmatrix}$$

When the decision matrix is multiplied by W column vector, the L column vector is formed. At the same time, this distribution also indicates the order of importance of decision points.

$$L = \begin{bmatrix} S_{11} & S_{12} & \cdots & S_{1n} \\ S_{21} & S_{22} & \cdots & S_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ S_{m1} & S_{m2} & \cdots & S_{mn} \end{bmatrix} x \begin{bmatrix} w_1 \\ w_2 \\ . \\ . \\ . \\ w_n \end{bmatrix} = \begin{bmatrix} l_{11} \\ l_{21} \\ . \\ . \\ . \\ l_{m1} \end{bmatrix}$$

Choosing the alternative with the highest rate as a result of these comparisons and weights may be the best solution to the problem of the decision-maker.

3. Implementation

This study was developed using AHP, a multi-criteria decision-making methodology, to help human resource managers (decision-makers) make decisions in the process of staff selection and to ensure that this process can be concluded in an easier and more practical way. When developing the application, HTML, PHP, JavaScript, MySQL were used.

1. **Determine of personnel selection problem**

   The decision-making problem has been defined as the fact that the people who apply for an appointment opened by the human resources department are not able to perform a healthy measurement, the elimination of those who do not comply with the clearly defined criteria, and the inability to effectively analyze the first.

2. **Determine of criteria:** The used criteria are as follows.

   - Educational Status
   - University
   - Experience (as year)

3. **Determine of alternatives (candidate personnel)**

   In this step, candidate personnel extract data from the database. The candidates apply for a job on application.

4. **Determination of relative and rating weights**

   In implementation, a section has been created in which the decision-maker's importance levels can be determined by himself.

5. **Determination of pairwise comparison matrix for alternatives**

   A table has been created to calculate the comparison matrix values. The scores in the pairwise comparison matrix, that is, the significance ratings are based on a difference table and the calculations are based on these values. This difference table is shown as follows.

Table 2: Difference between scores table.

Difference Between Scores	Values
Values1 – Values2 = 0	1
0 ≤ Values1 – Values2 < 1	1
1 < Values1 – Values2 < 3	2
Values1 – Values2 = 3	3
3 < Values1 – Values2 < 5	4
Values1 – Values2 = 5	5
5 < Values1 – Values2 < 7	6
Values1 – Values2 = 7	7
7 < Values1 – Values2 < 9	8
Values1 – Values2 = 9	9
−3 < Values1 – Values2 < 0	1/2
Values1 – Values2 = −3	1/3
−5 < Values1 – Values2 < −3	1/4
Values1 – Values2 = −5	1/5
−7 < Values1 – Values2 < −5	1/6
Values1 – Values2 = −7	1/7
−9 < Values1 – Values2 < −7	1/8
Values1 – Values2 = −9	1/9
Values1 – Values2 > −9	1/9
Source: Created by the author.	

3.1. Implementation interface

The home screen contains other management panes. This section, which consists of open and close tabs, allows the application register, decision-making, elected account to appear on the list of all applicants. Application usage, administrator (decision-maker), user reference screen, calculation screens and other screens are shown are as follows (Figure 2).

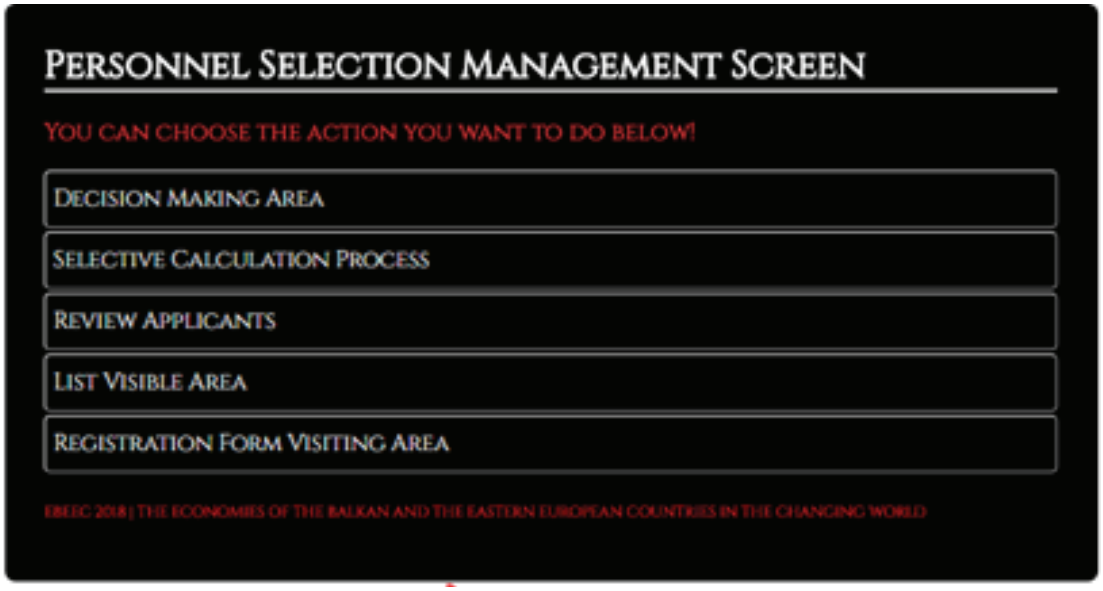

Figure 2: All User interfaces (general, decision-maker, candidates). **Source:** Created by the author.

Step 1: In this screen, the candidates fill in an application form (Figure 3).

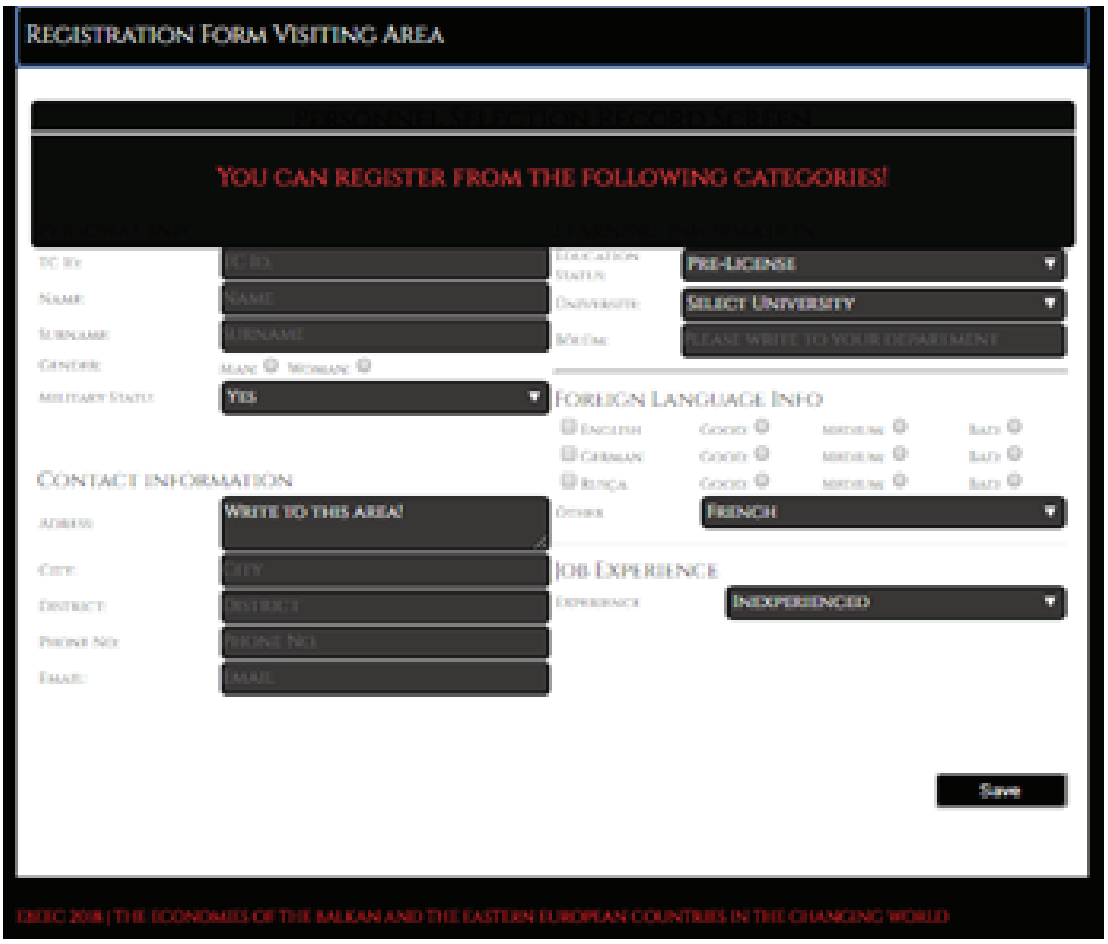

Figure 3: Registration screen. **Source:** Created by the author.

When the press the save button, all information of candidates save to database.

Step 2: On this screen, the decision-maker gives priority to the criteria in order to find the most suitable candidate for their preferences. Then decide which of the criteria you want by making multiple selections, and when you press the Calculate with AHP button, the solution algorithm runs. Decision-making screen is shown as follows (Figure 4).

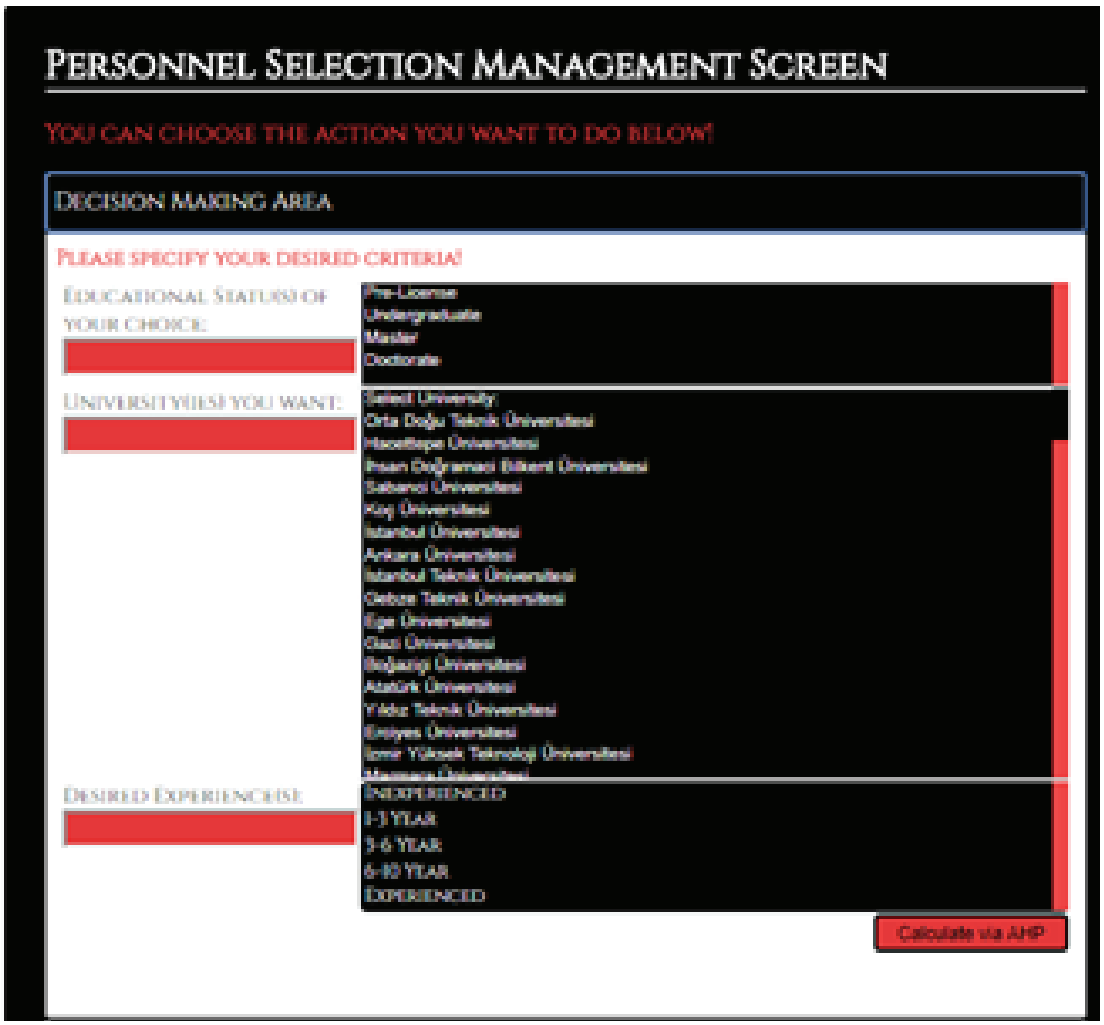

Figure 4: Decision-making screen. **Source:** Created by the author.

When the press calculate via AHP button, decision result comes to screen.

On this screen, the decision-maker makes multiple selections and determines the weights of the criteria. After the calculation is done, the screen comes with the candidates evaluated and the most suitable candidates. This decision result screen is shown as follows (Figure 5).

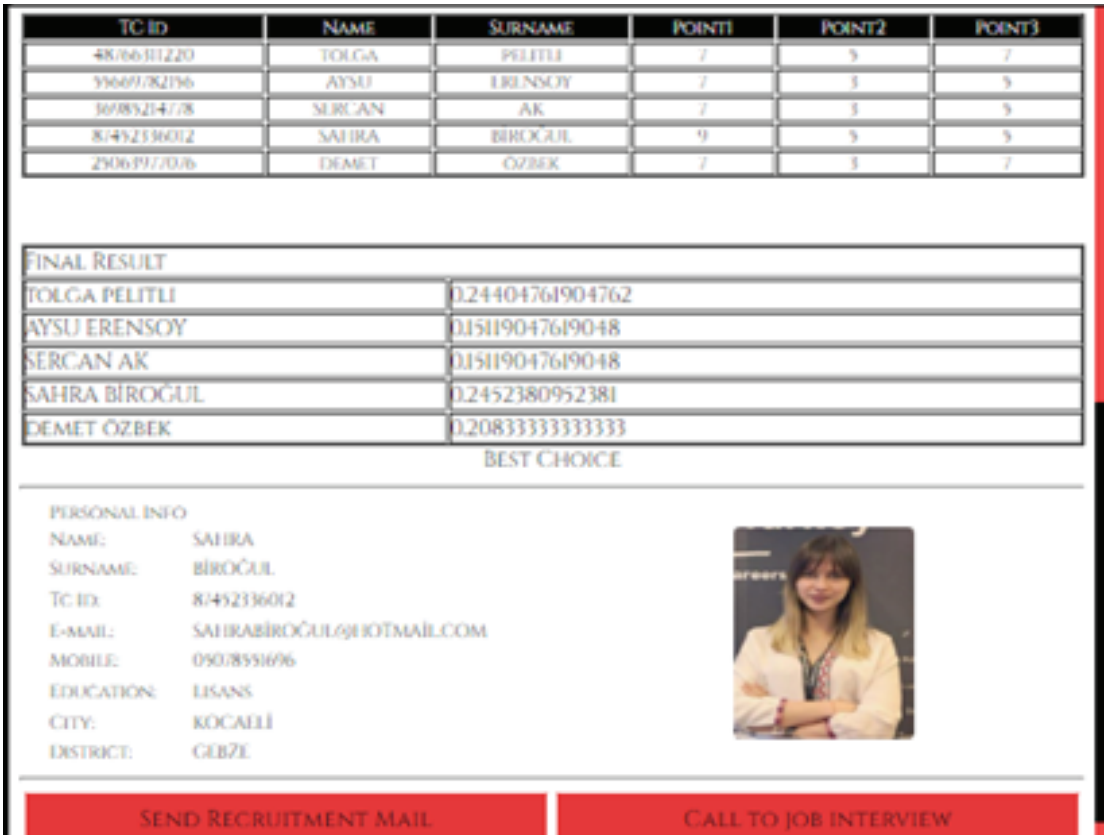

Figure 5: Decision result. **Source:** Created by the author.

In this screen, two buttons are shown to the decision-maker in order to communicate with the candidate coming to the screen. Depending on the decision-maker's preference, the person is provided with an informative mailing to the person by pressing the recall button or the call button for the job interview.

4. Conclusion

The human resources managers in the decision-making position have a 'right staff' approach that cannot be ignored for the staff selection process. In this approach, the right, appropriate staffing and selection process is a multi-criteria decision-making problem. In staff selection problems, first, decision-makers see that an additional staff is needed. The criteria for candidates to be recruited should be consistent with the definition of job.

Nowadays, every organization aspires to have certain criteria for its staff. This situation is important for both the organization vision and the personnel vision. human resources managers are concerned with more than one criterion in staff selection process. Elimination procedures based on these criteria facilitate the evaluation process.

the screening process to be carried out among hundreds of job applications made under normal conditions for a job application is made with limited opportunities or is not possible at all. In today's applications, some filtering process can be done. However, there may be data that are ignored during this filtering, which cannot be taken into the evaluation process for various reasons. this negative situation can create a process of staff selection that is unsuccessful for organizations.

In this study, as a solution to the personnel selection problem, a model for the Human Resources department, managers and decision-makers was determined. This model was developed based on a web based application which is based on the Analytical Hierarchy Process method from multiple criteria decision-making methods. This application has been developed in order to make the selection process of human resources managers simpler and faster and to support them. Developed for staff selection processes, it is possible to integrate and develop this application in multiple ways to different organizations.

The AHP algorithm used in the application is limited to three criteria but there are no restrictions on the number of candidates (alternatives) applied. Depending on the decision-maker's preference, people can continue to apply for employment during the open hours of applying for a job posting. However, the decision-maker may terminate the registration of 'close records'. As the number of alternatives increases in this study, according to the AHP theorem, the evaluation results of the candidates may approach each other and the differences between the alternatives may decrease. As a solution to this situation, the algorithm used in practice can be considered as the first part of the selection process. Existing candidates for a second evaluation process may continue to be evaluated by another elimination method.

This designed staffing solution model can be developed on a sectoral basis to serve this process. The specified criteria can be redefined according to sectors, short or long term purchases. Within the scope of this study, the number of criteria determined as three can be large according to the request of the decision-maker, the complexity of the problems and can be divided into sub criteria. there are no restrictions in practice in terms of the number of alternatives. But the decision-maker can intervene if he wants. This practice has been developed to support decision-makers in the processes they face. The qualities of the data obtained as a result of implementation facilitate decision-making. The human resources department of the organizations that make up the practice was designed in accordance with the staff selection problem process and made available to human resource managers (decision-makers). This application is included as 'decision support system' in mid-level and senior management

(management-level systems) by the parties to be developed depending on the structure of management information systems and the needs of management levels.

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