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Selection Of Information Technology Personnel For An Enterprise In The Process Of Industry 4.0 With The MultiMoora Method

Alparslan Serhat Demir*[1], Mine Büşra Gelen[2]

Abstract

Meeting the need for appropriate personnel for enterprises is a major decisive factor that directly affects the quality of the workforce as well as the quality of production and service processes. With the emergence of the Industry 4.0 concept, the expectations of the quality of the personnel working in the IT sector are increasing day by day. This increase in expectations makes it difficult to assess in the recruitment process. This requires an objective assessment of many criteria at the same time. In this study, the need of an IT (Information Technologies) personnel of a enterprise operating in the IT sector was met with the MultiMoora (Moora plus the full multiplicative form) method, which is one of the multi criteria decision making methods. In the study, the basic components of the Multimoora method; Moora-Ratio Method, Moora-Reference Point Approach and Full Multiplicative Form methods were applied separately and the most suitable IT personnel was selected by the theory of dominance.

Keywords: Personnel Selection, MultiMoora, Multi-Criteria Decision Making, Industry 4.0, The Theory of Dominance.

1. INTRODUCTION

Today, the development of technology and industry has increased the expectations of the qualities of the personnel that enterprises will add to their own structures. It is very important that the qualifications of the personnel are in harmony with the work to be done, the quality is increased in the field of production and service and the expectations of the customers can be met at the desired time and level. For this reason, enterprises care about the choice of personnel. Especially for the enterprises operating in the field of information technologies, the emergence of the concept of Industry 4.0 in the context of the big changes in the technology in recent years and the importance of the enterprises to the work done in this respect, necessitated the addition of new criteria during the evaluation of the IT personnel in the recruitment process.

In this study, the problem of personnel selection of an enterprise in the field of information technology is tackled. In the evaluation of the 6 candidates who applied to the enterprise, 14 criteria were used; oral communication skills, work experience, foreign language level, working in teams, emotional instability, software and software tools usage level, being open to innovation, self reliance, strategic decision making, knowledge of database management, stress coping, following

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technological developments, knowledge of artificial intelligence techniques and knowledge level for components of Industry 4.0.

Based on the 14 criteria determined, 6 candidates were assessed by the MultiMoora method, one of the multi-criteria decision-making methods. The Ratio System, the Reference Point Approach and the Full Multiplicative Form methods are applied in the MultiMoora method. With these methods, three different rankings of candidate personnel were obtained. The resulting sequences were transformed into a single sequence by the theory of dominance and the MultiMoora result was obtained. The personnel ranked first in the MultiMoora sequence was chosen as the preferred personnel for the enterprise.

2. LITERATURE REVIEW

In the literature, it is seen that multi-criteria decision making methods are frequently preferred in personnel selection studies. Liang &Wang (1994) proposed a multi-criteria personnel selection algorithm in which fuzzy linguistic values and non-fuzzy objective test scores are evaluated together [15]. Özgörmüş et al. (2005) selected the personnel of an enterprise operating in the food sector with fuzzy AHP [24]. Güngör et al. (2009) applied the Fuzzy Analytic Hierarchy Process (FAHP) method, which evaluates both qualitative and quantitative criteria, in the selection of personnel [16].

Dursun & Karsak (2010) proposed a fuzzy multi-criteria decision making method which is similar to Topsis, using fusion principles of technique and 2-tuple linguistic representation model for the problem of personnel selection [12].

Afshari et al. (2010), the candidates who are in the same quality among the candidates were determined by the Electre method and the appropriate personnel was selected by applying the AHP method to these candidates [7]. Lin (2010) conducted a personnel selection with analytic network process (ANP) and fuzzy data envelopment analysis (DEA) for an enterprise in Taiwan [22]. Zhang & Liu (2011) proposed a heuristic fuzzy multi-criteria group decision making method that uses Gray relational analysis (GRA) to rank and select alternatives and a heuristic fuzzy entropy to obtain entropy weights of criteria [13].

Baležentis et al. (2012) proposed and implemented MULTIMOORA-FG, which was created by expanding the fuzzy MultiMoora for linguistic reasoning with group decision [14]. Kabak (2013) proposed a model with fuzzy DEMATEL and fuzzy ANP for solving the problem of personnel selection [23]. Eroğlu et al. (2014) evaluated the preliminary applications of candidates by the ORESTE method and identified the candidates to be invited to the interview phase, which is one of the personnel procurement processes [10]. Tepe & Görener (2014), using the weights of criteria determined by using AHP method in MOORA, have selected to appropriate personnel for a corporate enterprise operating in Turkey [9].

AHP and TOPSIS methods have been used together in the selection of sales representatives who will work in retail chain stores in the information technology sector by Doğan & Önder (2014) [25]. In the selection of academic personnel by Vatansever & Oncel (2014), fuzzy AHP and fuzzy TOPSIS were applied together [26]. Personnel selection for more than one department was carried out by Yıldız & Aksoy (2015) by the AHP method in an enterprise operating in the automotive subsidiary industry [6].

Karabašević et al. (2015) used SWARA and ARAS methods together to evaluate candidates for a sales manager position in the telecommunications industry [8]. The service nurse selection of a private hospital by Adalı (2016) was carried out by determining the criterial weights by the AHP method and applying the EVAMIX (EVAluation of Mixed Data) and TODIM (Iterative Multi Criteria Decision Making) methods separately [11]. The selection of appropriate personnel in the banking sector by Değermenci & Ayvaz (2016) was provided by using fuzzy TOPSIS [27].

Cetin & Icigen (2017), used the weights of criteria determined by using the SWARA method in the MOORA method and selected the front office manager of a 5 star accommodation operation in Antalya [5]. Samanlioglu et al. (2018) used fuzzy AHP and fuzzy TOPSIS methods together to select the most appropriate personnel for the IT department [28]. Ji et al. (2018) proposed a

projection-based TODIM method with MVNSs to overcome the shortcomings of the TODIM method and applied the proposed method to the problem of personnel selection.

When the studies on the problem of personnel selection are examined, it is seen that there are few studies using MultiMoora method which is one of the multi criteria decision making methods. The selection of a department manager for a telecommunications company by Baleţentis & Zeng (2013) was done by applying MultiMoora, extended with Type-2 fuzzy sets [29]. Karabasevic et al. (2015) proposed a model in the mining industry where SWARA and MULTIMOORA methods are applied together in the problem of personnel selection [30].

In this study, appropriate evaluation criteria were determined in order to meet the IT personnel need for an IT company in the process of Endustri 4.0, and the most suitable personnel selection was made with the MultMoora method, which is a multi criteria decision making technique.

3. INDUSTRY 4.0 AND PERSONNEL KNOWLEDGE LEVEL

The concept of Industry 4.0, which is seen as an industrial strategy, first appeared in 2011 [21]. The use of automation systems in production, the development of artificial intelligence techniques and manufacturing technologies play an active role in the emergence of Industry 4.0 [20]. The exchange of customer expectations has increased the complexity of the production processes of enterprises and has led the enterprises to the Industry 4.0 process in which production systems are constantly communicating with one another via the Internet [19]. There are 9 concepts that can be evaluated as components of Industry 4.0 and are frequently used to describe Industry 4.0. These concepts are listed as Autonomous Robots, Simulation, Horizontal and Vertical System Integration, The Industrial Internet of Things, Cybersecurity, The Cloud, Additive Manufacturing, Augmented Reality and Big Data and Analytics [18].

With Industry 4.0, the expectations that enterprises seek in their personnel have changed. The emerging new concepts reveal the necessity for the personnel to have knowledge in new fields. This situation is influential in the recruitment processes of the enterprises. Enterprises in process of Industry 4.0 should test the knowledge level for subject of Industry 4.0 of candidates in the recruitment process [17]. With industry 4.0, the importance of software technologies has come to the forefront. With Industry 4.0, a digitalization and automation process, many artificial intelligence techniques such as expert systems, robotics, fuzzy logic and genetic algorithms are becoming more important.

In this study, when the candidate personnel was evaluated during the selection of personnel, the concept of Industry 4.0 along with the change in the expectations of the qualifications of the personnel in the enterprises was taken into consideration. The understanding of the 9 components, which form the basis of the Industry 4.0 concept, is of great importance in the transition to the Industry 4.0 process. For this reason, in the process of personnel selection, the level of knowledge of the candidates about these 9 components is considered as the evaluation criteria. Artificial intelligence techniques, which are effective in the emergence of the Industry 4.0 concept and which are of great importance for the application of Industry 4.0, are frequently preferred in the automation process. In the process of Industry 4.0, with the use of artificial intelligence techniques, it is ensured that the systems can fully perceive the activities and thus reach the complete information about the activities performed. In addition, by using artificial intelligence techniques, it is possible to evaluate the information obtained by the system, to make inferences by the system within the framework of automation and to carry out activities in a controlled manner. Therefore, the use of artificial intelligence techniques intertwined with the concept of Industry 4.0 by the IT personnel involved in this process is highly effective in the successful completion of the process. In this study, the importance of this situation is reflected in the process of personnel selection by adding the ‘knowledge of artificial intelligence techniques’ criterion.

4. MULTIMOORA

The emergence of the MultiMoora (Moora plus the full multiplicative form) method is based on getting the Moora (the multi-objective optimization on the basis of ratio analysis) method into the literature by Brauers & Zavadskas (2006) [1]. The method was applied until 2010 by applying two methods, namely the Ratio Method and the Reference Point Approach, and evaluating the results together. Then Brauers & Zavadskas (2010) added the Full Multiplicative Form method to the Moora method and created the MultiMoora method which evaluated the three methods together [2]. The MultiMoora method is applied in the form of evaluating the results of the Ratio Method, the Reference Point Approach and the Full Multiplicative Form methods by using the the theory of dominance developed by the same authors. When the MultiMoora method is applied, first, an initial matrix is created in which the performance values of the alternatives are based on the criteria. The criterion that has positive effect on this matrix is specified as the maximum criterion and the criterion which is negative is specified as the minimum criterion.

$$X = \begin{array}{c} \\ A_1 \\ A_2 \\ \dots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \dots & C_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \dots & \dots & \dots & \dots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix} \end{array} \quad (1)$$

$$Maximum\ or\ Minimum$$

4.1. Moora

The Moora method consists of applying the first two steps of the MultiMoora method, the Ratio Method and the Reference Point Approach methods.

4.1.1. Ratio Method

The ratio method is the first step of the MultiMoora method. Before the steps of the method are applied, the initial matrix is constructed and this matrix is normalized by Eq. (2) [4].

Before the steps of the method, normalization operation is performed using Eq. (2) to the created initial matrix [4]. The implementation of this process yields a normalized matrix that include normalized values $x_{ij}{}^*$.

$$x_{ij}{}^* = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{m} x_{ij}2}} \quad (2)$$

$i = 1, 2, \dots, n; n\ the\ number\ of\ objectives$

$j = 1, 2, \dots, m; m\ the\ number\ of\ alternatives$

$x_{ij} = j.\ performance\ measurement\ value\ in\ terms\ of\ alternative\ i.criterion$

The steps to be followed during the application of the ratio method are as follows:

1st Step: All values in the normalized matrix are weighted as in Eq. (3) with the criterion weight w_i for the column in which they are located. By weighting the values, the weighted normalized matrix consisting of the weighted values v_{ij} obtain.

$$v_{ij} = w_i * x_{ij}{}^* \quad (3)$$

$w_i = weight\ of\ criterion\ i$

2nd Step: In the generated weighted normalized matrix, the sum of the minimum criterion values is subtracted from the sum of the maximum criterion values for each alternative. As a result of this procedure, Ratio Method scores $y_j{}^*$ are obtained for all alternatives.

$$y_j{}^* = \sum_{i=1}^{g} v_{ij} - \sum_{i=g+1}^{n} v_{ij} \quad (4)$$

$i = 1, \dots \dots, g\ objectives\ to\ be\ maximized$

$i = g+1, \dots \dots, n\ objectives\ to\ be\ minimized$

$g = number\ of\ objectives\ to\ be\ maximized$

$n - g = number\ of objectives\ to\ be\ minimized$

$y_j{}^* = j\ normalized\ value\ of\ alternative\ according\ to\ all\ criteria$

3rd Step: The Ratio Method result is obtained as the result of ranking the ratio method scores of the alternatives from large to small.

4.1.2. Reference Point Approach

The Reference Point Approach is the second step of the MultiMoora method. When applying the method, first of all, normalization and followed by weighting operations as in the Ratio Method is applied to the initial matrix values. As a result of these operations, the weighted normalized matrix is obtained. The steps to be followed during the acquisition of the result of method are as follows:

1st Step: On the weighted normalized matrix, the maximum value of the maximum criterion and the minimum value of the minimum criterion are determined as the reference value r_i of the criterion in the column in which the value lies.

2nd Step: The absolute values of the differences between the reference values and the matrix values are calculated. A new matrix is created with the calculated values.

$$|w_i r_i - v_{ij}| \tag{5}$$

3rd Step: Alternatives are sorted from small to large according to the maximum values in the rows of the new matrix created. This sequence refers to the ordering of the alternatives as a result of the Reference Point Approach.

$$min_j\{max_i(|w_i r_i - v_{ij}|)\} \tag{6}$$

4.2. The Full Multiplicative Form

The Full Multiplicative Form is the third step of the MultiMoora method. Unlike the Ratio Method and the Reference Point Approach, the initial matrix is not subjected to normalization during application. The implementation steps for the method are as follows:

1st Step: The values in the initial matrix x_{ij} are weighted by taking the exponent w_i. With this process, the weighted initial matrix is obtained.

$${x_{ij}}^{w_i} \tag{7}$$

2nd Step: In the weighted initial matrix, the multiplication of the maximum values A_j and the multiplication of the minimum values B_j are calculated for each alternative.

$$A_j = \prod_{i=1}^{g} {x_{ij}}^{w_i} \quad , \quad B_j = \prod_{i=g+1}^{n} {x_{ij}}^{w_i} \tag{8}$$

$A_j = product\ of\ the\ maximum\ column\ values\ for\ each\ alternative$

$B_j = product\ of\ the\ minumum\ column\ values\ for\ each\ alternative$

3rd Step: U_j values are obtained by applying the Eq. (9) to the calculated A_j and B_j values. On the basis of these values alternatives are sorted from large to small. With this sorting, the result of the Full Multiplicative Form is obtained.

$$U_j = A_j / B_j \tag{9}$$

$U_j = overall\ utility\ of\ alternative\ j$

4.3. The Theory of Dominance

The theory of dominance is the last step of MultiMoora method. The rankings obtained for alternatives as a result of the application of the Ratio Method, the Reference Point Approach and the Full Multiplicative Form is evaluated in this step. The 3 different rankings of alternatives are converted into a single ranking under the name MultiMoora ranking. While the theory of dominance is applied, some rules are used. MultiMoora result is obtained in the framework of these rules grouped as absolute dominance, generally dominating, transitivity, overall being dominated, equability and circular reasoning [3]. The definitions of these rules utilized in practice are as follows:

Absolute Dominance: If an alternative's ranking obtained from the three techniques are respectively (4-4-4), it is definitely dominant.

Dominance: If $(q < r < s < t)$, generally $(t - q - q)$ dominates $(s - r - r)$, $(q - t - q)$ dominates $(r - s - r)$ and $(q - q - t)$ dominates $(r - r - s)$.

Transitiveness: If q dominates r and r dominates s, then q will also dominate s.

Being Dominated: It is the case in which, for instance, $(q - q - q)$ overall dominates $(r - r -$

r), which is overall being dominated by $(q - q - q)$.

Equability: For instance, if 2 alternatives have the form of $(p - p - p)$ and $(p - p - p)$, this means absolute equability. If 2 of the 3 three techniques have alternatives in the form of $(5 - p - 12)$ and $(7 - p - 8)$, this is called partial equability.

Contradictory situations other than those listed above may also occur. For example, Alternative A (4-12-6) dominates Alternative B (6-8-7), Alternative B (6-8-7) dominates Alternative C (7-11-5) and Alternative C (7-11-5) dominates Alternative A (4-12-6). In such a case the same ranking is given to the 3 alternatives, which is called *circular reasoning*.

5. IMPLEMENTATION

The application was realized in an IT enterprise operating in Kocaeli University Technopark. In the last recruitments, 6 candidates who applied to

operate were evaluated on the basis of 14 determined criteria. The data used in the study were determined by the expert decision maker in the enterprise. The hierarchical structure of the resulting multi-criteria decision making problem is shown in Figure 1.

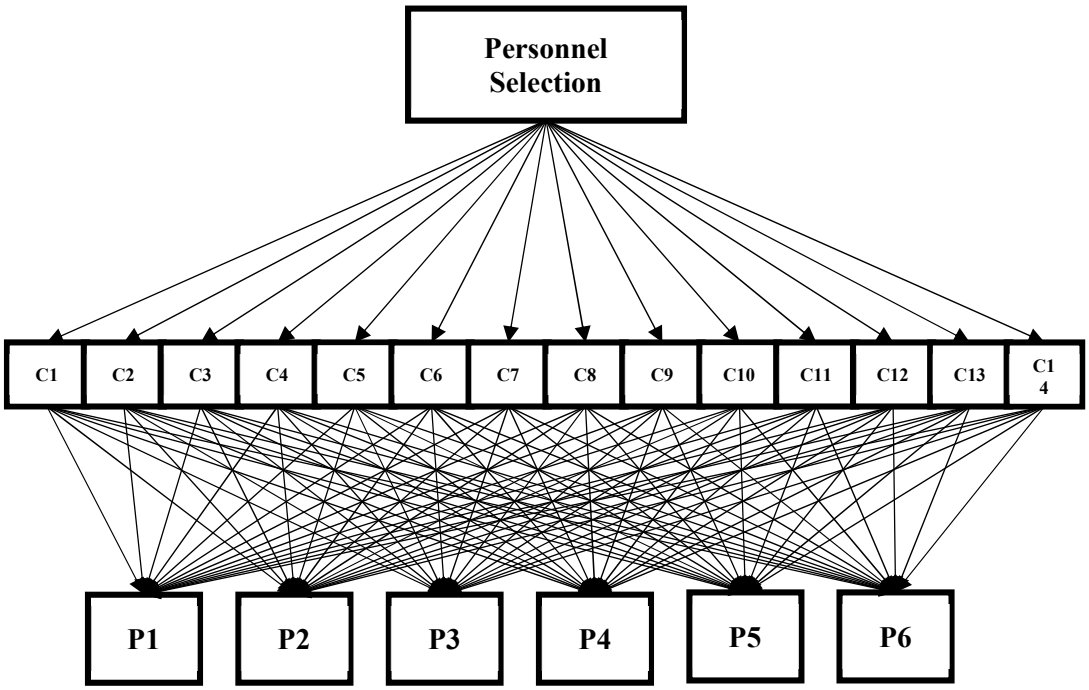

Figure 1. Hierarchical structure of the IT personnel selection problem

The initial matrix required during the implementation of the MultiMoora method was established by scoring with 1-9 points by the expert decision maker in the enterprise. Scores indicate the performance values of alternatives within criteria. The weight determination approach used in Factor ratings methodology was used to determine the criterion weights. First, the criterion with the lowest importance level was determined and given 1 point to this criterion. The weighting scores of the remaining criteria were calculated by asking the decision makers how many times the other criteria were important compared to the criterion with the lowest importance level. The

weight of each criterion is determined by the ratio of the weight points to the total weight points of the criteria and the weights of the criteria are between 0-1 (Table 1).

Table 1. IT candidates of personnel evaluation criteria.

Symbols of the Criterion	IT Personnel Selection Criteria	Weights of Criteria
C_1	Oral Communication Skills	0.089
C_2	Work Experience	0.022
C_3	Foreign Language Level	0.044
C_4	Working In Teams	0.089
C_5	Emotional Instability	0.044
C_6	Software And Software Tools Usage Level	0.111
C_7	Being Open To Innovation	0.067
C_8	Self Reliance	0.089
C_9	Strategic Decision Making	0.111
C_{10}	Following Technological Developments	0.089
C_{11}	Knowledge Of Artificial Intelligence Techniques	0.044
C_{12}	Knowledge Level For Components Of Industry 4.0.	0.022
C_{13}	Knowledge Of Database Management	0.111
C_{14}	Stress Coping	0.067

Then the steps of the MultiMoora method are applied to the problem where the initial matrix data and criteria weights are determined. The Ratio method, Reference Point Approach and the Full Multiplicative Form methods were applied in order and three different rankings of candidates of personnel were obtained. MultiMoora ranking of the candidate personnel was formed by testing the dominance of the obtained rankings with the theory of dominance.

Firstly, an initial matrix was established in which the values of the performance of the candidates of personnel in terms of 14 criteria determined by expert decision makers (Table 2). The 13 criteria with positive effect on this matrix maximum were determined as maximum and the criterion of 'Emotional instability' with negative effect was determined as minimum and shown on the matrix.

Table 2. Initial matrix x_{ij}.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}
	MAX	MAX	MAX	MAX	MIN	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX
P_1	8	6	4	8	2	9	8	9	8	8	5	1	8	8
P_2	6	6	5	5	3	7	8	5	6	5	2	2	6	6
P_3	9	4	4	8	2	8	6	9	7	7	3	1	9	9
P_4	8	1	7	5	4	6	8	7	7	4	2	1	9	4
P_5	3	3	2	7	4	8	8	3	9	8	4	1	9	7
P_6	8	4	7	3	1	4	8	9	6	3	1	1	6	8

The initial matrix is normalized using Eq. (2). The normalized matrix in Table 3 is obtained by multiplying the normalized values by the weights of criteria as in Eq. (3).

Table 3. Weighted normalized matrix v_{ij}.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}
	MAX	MAX	MAX	MAX	MIN	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX
P_1	0.040	0.012	0.014	0.046	0.013	0.057	0.028	0.044	0.050	0.047	0.029	0.007	0.046	0.030
P_2	0.030	0.012	0.018	0.029	0.019	0.044	0.028	0.025	0.038	0.029	0.012	0.015	0.034	0.023
P_3	0.045	0.008	0.014	0.046	0.013	0.050	0.021	0.044	0.044	0.041	0.017	0.007	0.051	0.034
P_4	0.040	0.002	0.025	0.029	0.025	0.038	0.028	0.034	0.044	0.024	0.012	0.007	0.051	0.015
P_5	0.015	0.006	0.007	0.041	0.025	0.050	0.028	0.015	0.056	0.047	0.023	0.007	0.051	0.027
P_6	0.040	0.008	0.025	0.017	0.006	0.025	0.028	0.044	0.038	0.018	0.006	0.007	0.034	0.030

Ratio Method scores of candidate staff were obtained by applying Eq. (4) to the weighted normalized matrix values. The Ratio Method ranking in Table 4 for alternatives are obtained by ordering the calculated values from large to small.

Table 4. Ranking of candidates according to the Ratio method.

	$\sum Max - \sum Min$	Ratio method Rank
P_1	0.439	1
P_2	0.318	5
P_3	0.412	2
P_4	0.324	4
P_5	0.349	3
P_6	0.315	6

When the Reference Point Approach steps are applied, the operations begin with a weighted normalized matrix. The maximum value of the maximum columns and the minimum value of the

minimum columns are determined as the reference value in the weighted normalized matrix (Table 5).

Table 5. Reference points r_i.

r_j	0.045	0.012	0.025	0.046	0.006	0.057	0.028	0.044	0.056	0.047	0.029	0.015	0.051	0.034

Eq. (5) is applied to all values found in the weighted normalized matrix. The matrix of Table 6 was created with the new values obtained as a result of this process.

Table 6. Converted criterion values.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}
	MAX	MAX	MAX	MAX	MIN	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX
P_1	0.005	0.000	0.011	0.000	0.006	0.000	0.000	0.000	0.006	0.000	0.000	0.007	0.006	0.004
P_2	0.015	0.000	0.007	0.017	0.013	0.013	0.000	0.020	0.019	0.018	0.017	0.000	0.017	0.011
P_3	0.000	0.004	0.011	0.000	0.006	0.006	0.007	0.000	0.013	0.006	0.012	0.007	0.000	0.000
P_4	0.005	0.010	0.000	0.017	0.019	0.019	0.000	0.010	0.013	0.024	0.017	0.007	0.000	0.019
P_5	0.030	0.006	0.018	0.006	0.019	0.006	0.000	0.030	0.000	0.000	0.006	0.007	0.000	0.008
P_6	0.005	0.004	0.000	0.029	0.000	0.032	0.000	0.000	0.019	0.029	0.023	0.007	0.017	0.004

By applying Eq. (6) to the matrix values in Table 6, the result of the Reference Point Approach for the alternatives is obtained (Table 7).

Table 7. Ranking of candidates according to the Reference Point Approach.

	$max_j(\lvert w_j r_j - v_{ij} \rvert)$	Reference Point Approach Rank
P_1	0.011	1
P_2	0.020	3
P_3	0.013	2
P_4	0.024	4
P_5	0.030	5
P_6	0.032	6

When the Full Multiplicative Form is applied, the initial matrix values are not normalized. All values in the initial matrix are weighted using Eq. (7). A weighted initial matrix is obtained as a result of the weighting process (Table 8).

Table 8. Weighted initial matrix

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}
	MAX	MAX	MAX	MAX	MIN	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX
P_1	1.203	1.041	1.064	1.203	1.031	1.277	1.149	1.216	1.260	1.203	1.074	1.000	1.260	1.149
P_2	1.173	1.041	1.074	1.154	1.050	1.241	1.149	1.154	1.220	1.154	1.031	1.016	1.220	1.127
P_3	1.216	1.031	1.064	1.203	1.031	1.260	1.127	1.216	1.241	1.189	1.050	1.000	1.277	1.158
P_4	1.203	1.000	1.090	1.154	1.064	1.220	1.149	1.189	1.241	1.131	1.031	1.000	1.277	1.097
P_5	1.103	1.025	1.031	1.189	1.064	1.260	1.149	1.103	1.277	1.203	1.064	1.000	1.277	1.139
P_6	1.203	1.031	1.090	1.103	1.000	1.167	1.149	1.216	1.220	1.103	1.000	1.000	1.220	1.149

For each alternative in the weighted initial matrix, A_j and B_j values were calculated using Eq. (8). The U_j values for each alternative are obtained by the ratio of the calculated A_j and B_j values to each other as in Eq.(9) (Table 9).

Table 9. A_j, B_j and U_j values of the Full Multiplicative Form.

	A_j	B_j	U_j
P_1	6.728	1.031	6.524
P_2	5.045	1.050	4.805
P_3	6.341	1.031	6.148
P_4	5.113	1.064	4.808
P_5	5.247	1.064	4.933
P_6	4.582	1.000	4.582

The U_j values are sorted from large to small and the Full Multiplicative Form order of the alternatives is obtained (Table 10).

Table 10. Ranking of the candidates according to the Full Multiplicative Form.

	U_j	Full Multiplicative Form Rank
P_1	6.524	1
P_2	4.805	5
P_3	6.148	2
P_4	4.808	4
P_5	4.933	3
P_6	4.582	6

By applying the Ratio Method, the Reference Point Approach and the Full Multiplicative Form methods, alternative rankings of 3 methods were obtained. Obtained rankings were evaluated by the theory of dominance. With the application of the theory of dominance, 3 rankings were transformed

into single ranking and MultiMoora ranking were obtained (Table 11).

Table 11. Obtaining MultiMoora ranking.

	Ratio Method	Reference Point Approach	Full Multiplicative Form	MultiMoora
$\boldsymbol{P_1}$	1	1	1	1
$\boldsymbol{P_2}$	5	3	5	5
$\boldsymbol{P_3}$	2	2	2	2
$\boldsymbol{P_4}$	4	4	4	4
$\boldsymbol{P_5}$	3	5	3	3
$\boldsymbol{P_6}$	6	6	6	6

When the MultiMoora result in Table 11 of 6 candidates evaluated with 14 criteria specified is examined, it is seen that the P_1 candidate in the first place is the most suitable personnel for the enterprise. P_5 has become the candidate personnel with the second preference order for the enterprise. P_2 candidate for the enterprise are in the third place in preference. The P_4, P_3 and P_6 candidates have become the preferred candidates for the 4th, 5th and 6th order respectively for the enterprise. In the direction of the results, the order of preference of the candidates of personnel are P_1>P_5>P_2>P_4>P_3>P_6.

6. CONCLUSION

With the development of the industry, the expectations of personnel qualifications have increased. Especially due to technological developments, the selection of personnel for enterprises operating in the IT sector is of great importance. Today, the emergence of the Industry 4.0 concept and becoming an important issue for enterprises leads enterprises to evaluate the qualities that IT personnel possess with a new point of view. In this study, the subject of meeting the need of the personnel of an enterprise operating in the IT sector is tackled. It was aimed to select the most suitable personnel among the 6 candidates who applied to the enterprise. Considering the requirements of Industry 4.0, the criteria required for the evaluation of 6 candidates were determined. The MultiMoora method, one of the multi criteria decision making methods, has been used to ensure that candidates of personnel are evaluated within the specified 14 criteria. As a result of the application, the selection of the most suitable IT personnel for the enterprise was provided. As a result of the application, the P_6 personnel, who are at the bottom of the list, were not recruited.

The difficulty of evaluating multiple criteria at the same time allows enterprises to make easier and more objective decisions by directing them to the use of these and similar techniques during personnel selection processes. Similar methods can be integrated into the software and presented to the personnel planning departments for use by the enterprises.

REFERENCES

[1] W. K. M. Brauers and E. K. Zavadskas, “The MOORA method and its application to privatization in a transition economy,” Control and Cybernetics, 35(2), 445-469, 2006.

[2] W. K. M. Brauers and E. K. Zavadskas, “Project management by MULTIMOORA as an instrument for transition economies,” Technological and Economic

Development of Economy, 16(1), 5-24, 2010.

[3] W. K. M. Brauers and E. K. Zavadskas, "Robustness of MULTIMOORA: a method for multi-objective optimization," Informatica, 23(1), 1-25, 2012.

[4] S. Datta, N. Sahu and S. Mahapatra, "Robot selection based on grey-MULTIMOORA approach," Grey Systems: Theory and Application, 3(2), 201-232, 2013.

[5] E. I. Cetin and E. T. Icigen, "Personnel Selection Based on Step-Wise Weight Assessment Ratio Analysis and Multi-Objective Optimization on the Basis of Ratio Analysis Methods," World Academy of Science, Engineering and Technology, International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering, 11(11), 2538-2542, 2017.

[6] M. S. Yıldız and S. Aksoy, "Analitik Hiyerarşi Prosesi ile Personel Seçimi Üzerine Bir Çalışma," Abant İzzet Baysal Üniversitesi Sosyal Bilimler Enstitüsü Dergisi. 15(1), 59-83, 2015.

[7] A. R. Afshari, M. Mojahed, R. M. Yusuff, T. S. Hong and M. Y. Ismail, "Personnel selection using ELECTRE," Journal of Applied Sciences, 10, 3068-3075, 2010.

[8] D. Karabašević, D. Stanujkić and S. Urošević, "The MCDM Model for Personnel Selection Based on SWARA and ARAS Methods," Management (1820-0222), (77), 2015.

[9] S. Tepe and A. Görener, "Analıtık Hıyerarsı Sürecı Ve Moora Yöntemlerının Personel Seçımında Uygulanması/An Implementatıon Of Analytıc Hıerarchy Process And Moora Methods On The Employee Selectıon," Istanbul Ticaret Universitesi Fen Bilimleri Dergisi, 13(25), 1, 2014.

[10] E. Eroğlu, B. F. Yıldırım and M. Özdemir, "Çok Kriterli Karar Vermede "Oreste" Yöntemi ve Personel Seçiminde Uygulanması," Yönetim: İstanbul Üniversitesi İşletme İktisadı Enstitüsü Dergisi, (76), 1-19, 2014.

[11] E. A. Adalı, "Personnel Selection In Health Sector with EVAMIX and TODIM Methods," Alphanumeric Journal, 4(2), 69-84, , 2016.

[12] M. Dursun and E. E. Karsak, "A fuzzy MCDM approach for personnel selection," Expert Systems with applications, 37(6), 4324-4330, 2010.

[13] S. F. Zhang and S. Y. Liu, "A GRA-based intuitionistic fuzzy multi-criteria group decision making method for personnel selection," Expert Systems with Applications, 38(9), 11401-11405, 2011.

[14] A. Baležentis, T. Baležentis and W. K. Brauers, "Personnel selection based on computing with words and fuzzy MULTIMOORA," Expert Systems with applications, 39(9), 7961-7967, 2012.

[15] G. S. Liang and M. J. J. Wang, "Personnel selection using fuzzy MCDM algorithm," European journal of operational research, 78(1), 22-33, 1994.

[16] Z. Güngör, G. Serhadlıoğlu and S. E. Kesen, "A fuzzy AHP approach to personnel selection problem," Applied Soft Computing, 9(2), 641-646, 2009.

[17] S. Shamim, S. Cang, H. Yu and Y. Li, "Management approaches for Industry 4.0: A human resource management perspective," 2016 IEEE Congress on Evolutionary Computation (CEC), 5309-5316, 2016.

[18] M. Rüßmann, M. Lorenz, P. Gerbert, M. Waldner, J. Justus, P. Engel and M. Harnisch, "Industry 4.0: The future of productivity and growth in manufacturing

industries," Boston Consulting Group, 9, 2015.

[19] A. Yıldız, "Endüstri 4.0 ve akıllı fabrikalar," Sakarya University Journal of Science, 22(2), 548-558, 2018.

[20] S. Dilibal and H. Şahin, "İşbirlikçi Endüstriyel Robotlar ve Dijital Endüstri," International Journal of 3D Printing Technologies and Digital Industry, 2(1), 86-96, 2018.

[21] N. Gabaçlı and M. Uzunöz, "IV. Sanayi Devrimi: Endüstri 4.0 ve Otomotiv Sektörü," ICPESS International Congress on Politic, Economic and Social Studies, No. 3, 149-174, 2017.

[22] H. T. Lin, "Personnel selection using analytic network process and fuzzy data envelopment analysis approaches," Computers & Industrial Engineering, 59(4), 937-944, 2010.

[23] M. Kabak, "A Fuzzy DEMATEL-ANP Based Multi Criteria Decision Making Approach For Personnel Selection," Journal of Multiple-Valued Logic & Soft Computing, 20, 2013.

[24] E. Özgörmüş, Ö. Mutlu and H. Güner, "Bulanık AHP ile personel seçimi," V. Ulusal Üretim Araştırmaları Sempozyumu, İstanbul Ticaret Üniversitesi, 111-115, 2005.

[25] A. Doğan and E. Önder, "İnsan Kaynakları Temin ve Seçiminde Çok Kriterli Karar Verme Tekniklerinin Kullanılması ve Bir Uygulama," Journal of Yasar University, 9(34), 2014.

[26] K. Vatansever and M. Oncel, "An Implementation of Integrated Multi-Criteria Decision Making Techniques for Academic Staff Recruitment," Journal of Management Marketing and Logistics, 1(2), 111-126, 2014.

[27] A. Değermenci and B. Ayvaz, "Bulanık ortamda TOPSIS yöntemi ile personel seçimi: katılım bankacılığı sektöründe bir uygulama," İstanbul Ticaret Üniversitesi Fen Bilimleri Dergisi, 15(30), 77-93, 2016.

[28] F. Samanlioglu, Y. E. Taskaya, U. C. Gulen and O. Cokcan, "A Fuzzy AHP–TOPSIS-Based Group Decision-Making Approach to IT Personnel Selection," International Journal of Fuzzy Systems, 20(5), 1576-1591, 2018.

[29] T. Baležentis and S. Zeng, "Group multi-criteria decision making based upon interval-valued fuzzy numbers: an extension of the MULTIMOORA method," Expert Systems with Applications, 40(2), 543-550, 2013.

[30] D. Karabasevic, D. Stanujkic, S. Urosevic and M. Maksimovic, "Selection of candidates in the mining industry based on the application of the SWARA and the MULTIMOORA methods," Acta Montanistica Slovaca, 20(2), 2015.