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RESEARCH ARTICLE / ARAŞTIRMA MAKALESİ

Personnel Selection Based on Integrated Multi-Criteria Decision Making Techniques

Entegre Çok Kriterli Karar Verme Tekniklerine Dayalı Personel Seçimi

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Abstract
Personnel selection is the most important process in human resources management discipline since a right selection contributes to other human resources management functions directly. An effective match indicates the quality of human resources department in an establishment. The process of selecting the most matching personnel is regarded as a 'Multi Criteria Decision Making' problem because of various criteria (qualitative and quantitative) for specific business positions. Hence, 'Multi Criteria Decision Making' techniques are very suitable to solve recruitment problems via finding the optimal candidate for a job position. This paper proposes a model that includes Decision Making Trial and Evaluation Laboratory (DEMATEL), Analytical Network Process (ANP) and Elimination and Choice Expressing the Reality (ELECTRE) tools for the first time to overcome this problem. In the first step of the methodology, network relations of the job criteria are identified by DEMATEL method. Afterwards, the network relations are used as inputs in the ANP process and the importance weights of the job criteria are obtained via ANP method. Finally, ELECTRE method is implemented to rank the applicants. In all the steps, expert opinions are utilized and the integrated methodology is implemented in a corporation to show its applicability. Therefore, this study contributes to the literature both theoretically and practically.

Keywords: Personnel selection, DEMATEL, ANP, ELECTRE

Öz
Personel seçimi, doğru bir şekilde yapıldığında, diğer insan kaynakları fonksiyonlarına da katkı sağlayan insan kaynakları yönetim disiplininin önemli bir sürecidir. Uygun personel seçimleri bir işletmenin insan kaynakları bölümünün kalitesini de göstermektedir. Belirli iş pozisyonları için yapılan personel seçimi gerek nicel gerekse de nitel ölçütler içermesinden dolayı "Çok Kriterli Karar Verme" problemi olarak değerlendirilmektedir. Bu bağlamda, "Çok Kriterli Karar Verme" teknikleri en iyi adayın belirlenmesi noktasında uygun çözümler üretebilmektedir. Bu çalışmada DEMATEL, ANP ve ELECTRE tekniklerinin ilk defa bir arada kullanıldıkları bir metot önerilmektedir. Önerilen metodun ilk adımında personel seçim ölçütleri arasındaki ağ ilişkileri DEMATEL metodu ile belirlenmektedir. Sonrasında, ağ ilişkileri ANP sürecinde girdi olarak kullanılmakta ve ölçüt önem ağırlıkları bulunmaktadır. En son olarak da ELECTRE metodu başvuran adayları sıralamak da kullanılmaktadır. Bütün adımlarda uzman görüşleri alınmış ve önerilen metodun geçerliliğinin gösterilmesi için bir işletmede uygulama yapılmıştır. Böylece, bu çalışma ile literatüre gerek teorik gerekse de pratik katkı sağlanmaktadır.

Anahtar Kelimeler: Personel seçimi, DEMATEL, ANP, ELECTRE

I. INTRODUCTION

In 20th century, human resources management gains more importance since customer demands and competition in the firms increase. Significance of manpower in a company to accomplish the objectives makes human resources management more important. Human resources department of a business has many functions. These are planning, organizing, directing, controlling, recruitment, job analysis, performance appraisal, training, salary administration, personnel research and record. Recruitment is the most critical function among these functions. When human resources department in an organization needs additional workforce,

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there are a few alternatives including full scale recruitment and selection process and hiring employees. Recruitment is the process of attracting people on a timely basis, in required numbers and specifications to apply for job positions in an enterprise. Recruitment and personnel choice affect the firms directly and selection procedure is a very critical function of an organization's management. Selecting ambitious and skilled candidates assist organizations to earn success.

In decision making process, a selection is carried out among several alternatives to achieve a specific goal, the optimal choice is determined via various methods. Personnel selection problem is assumed as a kind of Multi Criteria Decision Making (MCDM) problem. MCDM problems include techniques that use more than one criterion to obtain the best solution. However, the opinions of the decision makers (DMs) and this subjective approach make the personnel selection problem more difficult. In addition, the personnel selection problem framework has both qualitative and quantitative criteria. Therefore, MCDM techniques are one of the best methods to cope with the complex structure of the personnel selection problem.

The paper combines three different methods and proposes an integrated methodology for personnel selection. MCDM tools including DEMATEL, ANP and ELECTRE are utilized together for the first time for personnel selection. The reason for using DEMATEL depends on its strength for determining the network relations between the factors. Afterwards, ANP is used since it enables to find the importance weights in a network structure. Finally, ELECTRE technique is utilized depending on its suitability and strength for ranking the alternatives considering outranking relations. Besides the individual superiorities of the techniques, it is also benefited from the synergy of using these three techniques together. However, this paper provides contributions both theoretically by proposing an integrated methodology utilizing three well-known robust techniques for the first time and practically by providing an implementation about personnel selection in industry.

The other parts of this paper are organized as follows: Section 2 presents the literature review including the criteria and methods utilized for personnel selection. In Section 3, the proposed methodology is presented with the techniques including DEMATEL, ANP and ELECTRE. Section 4 involves the implementation of the methodology in an organization and finally conclusion is provided with the references.

II. LITERATURE REVIEW

There are a great number of studies about personnel selection. Papers published after 1999 are studied here. 39 papers are examined in terms of solution methods, sector and job positions and depicted in Appendix (Table 12). Some of the studies are explained briefly in accordance with the sectors as follows.

In information technology industry, Wu and Lee (2007) applied fuzzy DEMATEL method to find out global manager candidates. Chen and Lee (2010) and Kelemenis and Askounis (2010) used FTOPSIS method to obtain productive results for recruitment. Akhlaghi (2011) implemented rough set exploration system for construction project manager position. Kelemenis et al. (2011) benefited from the advantages of FTOPSIS method with veto threshold. Zhang and Liu (2011) analyzed intuitionistic fuzzy multi-criteria group decision making method with GRA to personnel selection problem. Doğan and Önder (2014) applied a combined methodology using AHP and TOPSIS methods. Erdem (2016) implemented AHP in fuzzy environment for junior developer position.

In education sector, Ayub et al. (2009) used FANP method. Kabak and Kazançoğlu (2012) applied FAHP tool. Rouyendegh and Erkan (2013) developed a model using FE-LECTRE method. Kumar et al. (2013) utilized an integrated technique that involved SAW, WPM, AHP and TOPSIS. Saad et al. (2014) proposed a model using Hamming distance method with subjective and objective weights (HD-MSOW's).

In construction sector, Zavadskas et al. (2008), Shahhosseini and Sebt (2011) and Gilan et al. (2012) proposed methodologies utilizing COPRAS-G (COmplex Proportional ASsessment of alternatives with grey relations), Adaptive Neuro-Fuzzy Inference System and FAHP, Computing with words (CWW) tools respectively.

In automotive sector, Saremi et al. (2009) used FTOPSIS to improve quality of decision of personnel selection. In addition, Yıldız and Aksoy (2015) implemented AHP technique. In textile sector, Ozdemir (2013) proposed a hybrid methodology using AHP with stochastic dynamic programming and in telecommunication sector, Afshari et al. (2010) combined AHP and ELECTRE tools. Moreover, Efe and Kurt (2018) applied possibility degree based TOPSIS method for the selection of textile personnel in assembly line balancing problem.

On the other hand, there are also studies that are not stated on sectoral basis. Nabeeh et al. (2019) developed an integrated neutrosophic-TOPSIS approach for the selection of customer service manager. Ji et al. (2018) proposed a projection-based TODIM method under multi-valued neutrosophic environments for personnel selection and finally fuzzy axiomatic design principles were applied by Khandekar and

Chakraborty (2016) for the selection of manager in purchase department. Moreover, it is observed that there is not a study which utilizes the combination of DEMATEL, ANP and ELECTRE methods for personnel selection in the literature. Hence, this study is supposed to provide contribution to the literature by filling this gap.

III. THE PROPOSED METHODOLOGY

The methodology proposed in this study consists of four main stages including Preparation, DEMATEL, ANP and ELECTRE techniques. Within the first preparation stage, the criteria that will be used in personnel selection, candidates and the decision makers are determined. In the second stage, DEMATEL is applied to find the network relationship map of the criteria. Afterwards, in the third stage, ANP is applied to obtain the importance weights of the personnel selection criteria. Finally, in the last stage, ELECTRE is applied to rank the candidates. The details of the stages are indicated in Figure 1.

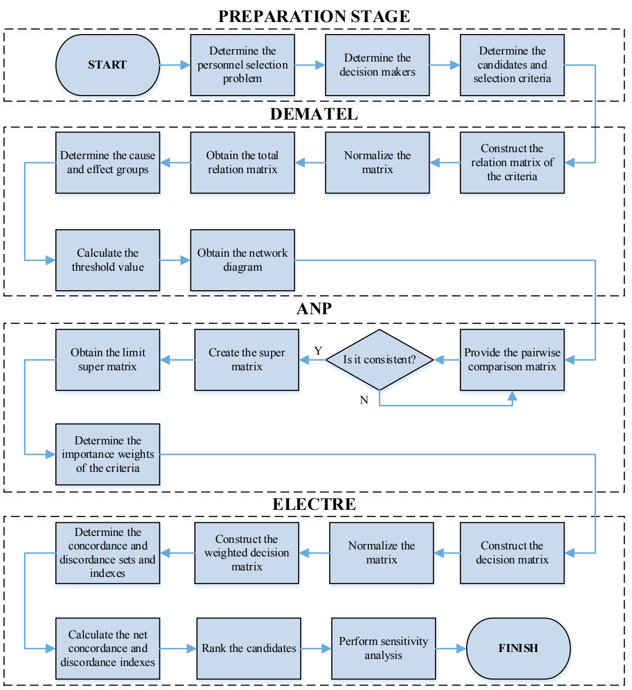

Figure 1 The proposed methodology

3.1 DEMATEL

At the end of 1971, DEMATEL methodology was presented and it was firstly used by the BMI agency of Switzerland (Kiakojuri et al., 2015). Since then, it has been used in various fields including; determining the key factors affecting the hospital performance (Afsharkazemi et al., 2013), exploring the key factors of corporate social responsibility (Chen and Chi, 2015), analyzing the social capital indicators (Kiakojuri et al., 2015) and so on.

The execution of DEMATEL method consists of six steps (Sumrit and Anuntavoranich, 2013):

1. Gathering expert's opinion and calculating the average matrix
2. Normalizing the initial direct-relation matrix
3. Obtaining the total relation matrix
4. Computing the row and column sums of matrix
5. Setting the value of threshold
6. Constructing the impact-relation map

Figure 1 depicts the algorithm in a detailed manner. Cause and effect relationship chart's acceptability affects the process, depending on the acceptability degree, steps 5 and 6 can be repeated.

Step 1: Gathering expert's opinion and calculating the average matrix

M experts and n factors are considered. Factors list that is organized in sets of i and j are asked to experts to express their opinions on the impact degrees the factors having on each other (pairwise comparison, at what level factor i affects factor j). A scale is constructed (e.g. a scale of 0-4; 0 = no influence, 1 = weak direct influence, 2 = moderate direct influence, 3 = strong direct influence, 4 = very strong direct influence). The level to which the expert evaluates factor i influences factor j is denoted as xij. A nxn non-negative matrix is constructed for every expert as Xk = [Xkij], where k is the evaluating expert number with $1 \le k \le m$. The matrix's mathematical notation is shown in Equation 1.

$$X = \begin{bmatrix} 0 & \cdots & X_{1n} \\ \vdots & \ddots & \vdots \\ X_{n1} & \cdots & 0 \end{bmatrix} \quad (1)$$

M matrices (X1, X2, X3,…,Xm) are derived from the experts. Every single matrix element is shown as xij which is the impact degree, i has on factor j. All the diagonal elements of matrices i-are set to zero since DEMATEL method doesn't assess self-influence of factors.

An average comprehension of the experts' opinions has to be attained. Initial direct-relation matrix is generated by obtaining the average of the matrix. This matrix can be represented as matrix Z=[zij] and obtained by the formula in Equation 2.

$$z_{ij} = \frac{1}{m} \sum_{i=1}^{m} x_{ij}^{k} \quad (2)$$

Step 2: Normalizing the initial direct-relation matrix

The average matrix Z is used to calculate normalized direct relation matrix. Total direct impact on the impact scale of the factor with the most direct impact on the other factors is represented in Equation 3.

$$\max_{1\leq i\leq n} \sum_{j=1}^{n} z_{ij} \quad (3)$$

The values of all elements in the normalized direct-relation "matrix D" are between [0,1] and the formulas to obtain normalized matrix are depicted in Equation 4.

$$D = \lambda * Z \quad (4)$$

Where λ is shown in Equation 5.

$$\lambda = \mathrm{Min}\left[\frac{1}{\max_{1\leq i\leq n} \sum_{j=1}^{n}|z_{ij}|}, \frac{1}{\max_{1\leq j\leq n} \sum_{i=1}^{n}|z_{ij}|}\right] \quad (5)$$

Step 3: Obtaining the total relation matrix

Total relationship is the direct and indirect relationship between factor pairs. It is assumed that the indirect impact matrix reaches to the null matrix and it is demonstrated in Equation 6.

$$\lim_{k\to\infty} D^k = 0 \quad (6)$$

0 is the null matrix and I is an n x n identity matrix. $(I-D)^{-1}$ formulation is shown in Equation 7.

$$\lim_{k\to\infty}(1 + D + D^2 + \cdots + D^k) = (I-D)^{-1} \quad (7)$$

Finally, the total relation matrix T is obtained and depicted in Equation 8.

$$T = D(I-D)^{-1} \quad (8)$$

Step 4: Computing row and column sums of matrix

Each column sum and row sum of the matrix T is calculated, r_i denotes the row sum of the ith row of matrix T and it represents the sum of direct and indirect impacts of factor i on the other factors. In addition, c_j denotes the column sum of the jth column of matrix T and it represents the sum of direct and indirect impacts that factor j has received from the other factors. The summation, ri + ci presents the total impacts given and received, that is, ri + ci represents the degree of the significant role that factor i plays in the entire system and if ri – ci is positive, then factor i has an impact on the other factors and a net cause occurs, else if, ri – ci is negative, then factor is affected by the other factors and a net receiver occurs.

Step 5: Setting the value of threshold α

Threshold value is determined to remove the effect of elements having minor impact in matrix T. In matrix T, each factor ij of matrix T gives information about how factor i influences the factor j, if all the information from matrix T was transferred to the Impact-Relation Map (IRM), it would be too complicated. Thus, the aim of elimination of complexity in IRM leads to set a threshold value α for the impact level. Threshold value is calculated by computing the average of elements in the matrix as shown in Equation 9.

Where N is the total number of elements in matrix T

$$\alpha = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}[t_{ij}]}{N} \quad (9)$$

Step 6: Constructing the impact-relation map (IRM)

This is the final step of the method and it is built by mapping all coordinate sets of (ri + ci, ri – ci) to display the complicated interrelationship. The factors which have impact value in matrix T greater than the threshold value α are selected and transferred to the IRM, the cause and effect diagram. This chart gives information about the most critical factors and the impact.

3.2 ANP

ANP is introduced by Thomas L. Saaty in 1980. This approach considers interdependencies of factors; impact, dependency and feedback are the basics of ANP. The method not only evaluates alternatives and criteria in selection, but also positive and negative outcomes of interactions of alternatives and criteria. It is a generalized form of AHP and it provides better and more realistic solutions to complex MCDM problems (Saaty, 1994) and has various application areas including location selection for hospitals (Lin and Tsai, 2010), performance measurement (Chen et al., 2012) and so on. ANP presents effective solutions for complex decision problems since the method requires a process to make a correct choice and contains various steps (Saaty and Vargas, 2013).

These are:

1. Defining the problem and constructing the decision model
2. Making pairwise comparisons and calculating local weights
3. Creating supermatrix
4. Ranking global weights

Step 1 – Defining the problem and constructing the decision model

In this step, the decision problem is defined and structured as network. Firstly, the goal of the process is set. Secondly, this goal is divided to clusters (component), factors, criteria and alternatives. Thirdly, by considering dependencies and feedbacks, relations are identified. Creating detailed structures that are capable of describing the problem, is critical because the validity of the decision is directly related to the structure and relations in the structure. ANP structures the problems as networks, generally a network is related to the effects of an element to other elements. Relations are identified between decision components and elements and a diagram is generated. Components and factors that are located in components constitute the network structure. Furthermore, all variables, criteria, sub-criteria and alternatives are identified. After identifying basic elements of the network, the relations between components and factors, feedbacks and dependencies are analyzed. A factor in a component can have interaction with a factor in another component or a factor in the same component. All these interactions are considered to identify the relations.

Step 2 – Making pairwise comparisons and calculating local weights

Pairwise comparisons are made. 1-9 scale which is introduced by Saaty and also used in AHP is utilized. Pairwise comparisons are made by considering the network and the factors that are related. ANP is based on the interactions of the main factors. Regarding the personal judgement of the decision maker, local priority weights are calculated. Eigenvector is used to obtain the weights. Finally, consistency ratios are determined and inconsistent matrices are checked.

Step 3 – Creating supermatrix

Supermatrix is a matrix which all interactions in the network are presented (Yang et al., 2015). Local priority vectors, which are obtained from pairwise comparisons, are written to the columns of the supermatrix. A supermatrix is a sectional matrix and each part in this matrix shows the relation between two factors in the system. If factors in a cluster don't have influence on other factors in another cluster, then 0 is put to related parts.

There are three types of supermatrix in ANP. These are unweighted or beginning supermatrix, weighted supermatrix and limit supermatrix. Unweighted or beginning supermatrix is obtained by replacing the priority vectors, that are the result of the pairwise comparisons. Weighted supermatrix is obtained by the multiplication of the priority values of the clusters and the eigenvector of the clusters. As a result, column sums of the weighted supermatrix equal to 1 and it turns to a stochastic matrix. Stochastic matrices have convergence property, when stochastic matrices are exponentiated, the values in the same row converge to each other and meet in a limit value (Abastant et al., 2011). Lastly, weighted supermatrix is exponentiated (2k+1) times to get the impacts of factors on each other in long term and it is shown in Equation 10, k is a random large number in the equation. Limit supermatrix is the result of exponentiating the weighted matrix by a great number of times.

$$\lim_{k \to \infty} W^k \tag{10}$$

Step 4 – Ranking global weights

Supermatrix determines the weights of the alternatives or factors compared. Values at a specific row of the limit supermatrix show the global priority value of the factor in that row. In selection problem, alternative with the greatest weight is the best alternative and in weighting problem, the factor with the greatest weight is the most important factor that affects the decision process (Saaty, 2008).

3.3 ELECTRE

ELECTRE is a MCDM method and it is developed by a team of European researchers in Consultancy Company SEMA in 1965 (Benayoun and Sussman, 1966).

ELECTRE is based on making a selection among the alternatives by comparing them with respect to the preference ranking. ELECTRE is one of the most applied outranking methods that reflect the decision makers' preferences. In addition, alternatives are compared with respect to the outranking relations and these relations represent dominancy among alternatives (Pang et al., 2011).

In this study, ELECTRE is implemented for the personnel selection problem and the execution of ELECTRE method consists of seven steps (Bari and Leung, 2007; Tunca et al., 2015; Yücel and Görener, 2016; Alper and Başdar, 2017):

1. Constructing the decision matrix
2. Normalizing the decision matrix
3. Obtaining the weighted decision matrix
4. Determining concordance and discordance sets
5. Calculating concordance and discordance indexes
6. Comparing outranking alternatives
7. Calculating net concordance and discordance indexes

Step 1 – Constructing the decision matrix

Decision matrix is an initial matrix and is created by the decision maker. Alternatives are placed in the rows and decision criteria are placed in columns as shown in Equation 11.

$$A_{ij} = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mn} \end{bmatrix} \tag{11}$$

m symbolizes number of alternatives, n symbolizes number of criteria and aij symbolizes the evaluation score of mth alternative with respect to nth criterion.

Step 2 – Normalizing the decision matrix

Decision matrix is normalized by using the following two formulas for profit and cost criteria respectively and are shown in Equations 12 and 13.

$$x_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{m} a_{kj}^2}} \quad for\ all\ i\ and\ j \tag{12}$$

$$x_{ij} = \frac{\frac{1}{a_{ij}}}{\sqrt{\sum_{k=1}^{m}\left(\frac{1}{a_{kj}}\right)^2}} \quad for\ all\ i\ and\ j \tag{13}$$

As a result, the following normalized decision matrix is found as in Equation 14.

$$X_{ij} = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \tag{14}$$

Step 3 – Obtaining the weighted decision matrix

Importance of criteria can differ thus Y matrix arises. Weights of criteria (Wi) should be specified by the decision maker and then normalized X matrix is multiplied by Wi as indicated in Equation 15 and V_{ij} weighted decision matrix is obtained and shown in Equation 16.

$$V_{ij} = W_j X_{ij}, \sum_{j=1}^{n} W_j = 1 \tag{15}$$

$$V_{ij} = \begin{bmatrix} w_1 x_{11} & \cdots & w_n x_{1n} \\ \vdots & \ddots & \vdots \\ w_1 x_{m1} & \cdots & w_n x_{mn} \end{bmatrix} \tag{16}$$

Step 4 – Determining concordance and discordance sets

Y matrix is processed to obtain the concordance and discordance sets. Decision points are compared with respect to the criteria. For every pairwise alternative comparison, criteria are divided to two different sets. In a concordance set, Ap and Aq (for all p, q and p ≠ q) Ap alternative is chosen instead of Aq alternative and it is shown in Equation 17.

$$C(p,q) = \{ j \mid V_{pj} \geq V_{qj} \} \tag{17}$$

If Ap alternative is worse than Aq alternative, a discordance set is created as in Equation 18.

$$D(p,q) = \{ j \mid V_{pj} < V_{qj} \} \tag{18}$$

In ELECTRE, each concordance set has a corresponding discordance set.

Step 5 – Calculating concordance and discordance indexes

Concordance and discordance indexes are utilized to assess the relationship of the elements or objects. Concordance index shown by C(a,b) indicates that if a is as better as b or not. On the other hand, discordance index shown by D(a,b) indicates the degree of certain preference of b to a. Concordance sets are used to create concordance matrix (C). The elements of matrix C are gathered by the formula in Equation 19.

$$C_{pq} = \sum_{j \in C_{pq}} W_j \tag{19}$$

C_{pq} concordance index can be easily calculated. For example if C_{12} = {1,4} then the value C_{12} element is W1 + W4 . C matrix is obtained as shown in Equation 20.

$$C = \begin{bmatrix} - & \cdots & c_{1m} \\ \vdots & \ddots & \vdots \\ c_{m1} & \cdots & - \end{bmatrix} \tag{20}$$

By using discordance set, discordance matrix (D) is obtained. The discordance matrix elements are obtained by the formula indicated in Equation 21.

$$D_{pq} = \frac{max_{j \in D_{pq}} |v_{pj} - v_{qj}|}{max_{\forall j} |v_{pj} - v_{qj}|} \tag{21}$$

D matrix is formed and depicted as in Equation 22.

$$D = \begin{bmatrix} - & \cdots & d_{1m} \\ \vdots & \ddots & \vdots \\ d_{m1} & \cdots & - \end{bmatrix} \tag{22}$$

Step 6 – Comparing outranking alternatives

After calculating concordance and discordance indexes, their elements are checked in a specified way and the alternatives which are inappropriate are eliminated. Greatness of concordance (Cpq) and smallness of discordance (Dpq) indexes determine how much Ap alternative outranks Aq. Firstly, average of C and average of D (C* and D*) are calculated for this, if Cpq >= C* and Dpq < D*, then Ap alternative is chosen instead of Aq alternative. The alternatives selected via ELECTRE method constitute kernel (K) which is created by considering the following two conditions (Tzeng and Huang, 2011).

An alternative in K doesn't outrank an another alternative in K.

An alternative that isn't in K is worse than at least one alternative in K, in the ranking of preference.

Step 7 – Calculating net concordance and discordance indexes

In case of existence of more than one alternative in kernel, net concordance and discordance indexes determine the alternative. They show which alternative outranks the others. The alternative which has the greatest value with respect to the net concordance index and similarly the smallest value with respect to the net discordance index is the solution set.

Hence, Cps are ranked in descending order and D_p D_p s are ranked in ascending order and net concordance and discordance indexes are calculated by the formulas shown in Equations 23 and 24.

$$C_{p} = \sum_{k=1,k\neq p}^{m} C_{pk} - \sum_{k=1,k\neq p}^{m} C_{kp} \quad (23)$$

$$D_{p} = \sum_{k=1,k\neq p}^{m} D_{pk} - \sum_{k=1,k\neq p}^{m} D_{kp} \quad (24)$$

Ultimately, the final ranking is obtained by selecting the greatest "C" and the smallest "D" value. Moreover, in case, there is a difference between the rankings in concordance and discordance indexes, as Bari and Leung (2007) state, the average of rankings can be obtained to get a final ranking.

IV. THE APPLICATION OF THE PROPOSED METHODOLOGY FOR ENGINEER SELECTION

The proposed methodology is applied in an industry for engineer selection. The organization which the application is carried out is mainly related to rubber part manufacturing. Since 1959, the company is a manufacturer of rubber parts for the industry. At the present time, the company produces rubber mixing, door bellows, gasket, inlet, outlet hoses, rubber metal bonded anti-vibration parts, grommets for wiring and cable harness systems, brake diaphragms and various engineering devices. In the organization, personnel selection application is conducted via a multi-stage process; in the first stage, a job interview is made with the candidates that meet the job advertisement requirements via phone by making an evaluation based on personality, technical skills and foreign language, whereas, in the second stage, conduction of exams (candidates score under 70 points are eliminated) and in the third stage, a job interview is made with the related department manager and manager's decision becomes the final decision. In the existing system, the related department manager does not use a specific system instead decides intuitively. In the proposed new approach, the first two stages remain the same however, in the third stage, the proposed methodology is applied. Hence the decisions are performed via a scientific framework. The related steps of the proposed methodology are provided in the following sections.

4.1 Preparation Stage

Within the preparation stage, the personnel selection criteria are determined via obtaining the views of human resource expert in the company and literature review and finalized as follows:

- Education (At least having bachelor degree in industrial, mechanical, mechatronics or material engineering)
- Experience
- Personality and Personal Skills
- Technical Skills and Requirements (Being a good MS Office User, Knowing IATF 16949, Kaizen, 5S quality systems)
- Foreign Language (Speaking and writing well in English or German)
- Vocational Flexibility (Being free to travel domestic or abroad)
- Exam Results (Points from the exam performed by the firm)

Moreover, there are seven candidates to be evaluated at the end of the pre-evaluation stages. The candidates are named as Cnd1, Cnd2,…,Cnd7.

4.2 DEMATEL Stage

In the second stage of the proposed methodology, DEMATEL technique is utilized so as to obtain the network relation map (NRM) which is used as an input in the ANP stage. The human resource expert's opinion is gathered to obtain decision matrix for DEMATEL. A scale is constructed between 0 and 4 (0 = no influence, 1 = weak direct influence, 2 = moderate direct influence, 3 = strong direct influence 4=very strong direct influence). The expert's opinion for seven criteria is displayed as in Table 1. For example, education criterion weakly affects experience criterion, education criterion doesn't affect vocational flexibility criterion, education criterion moderately affects personality and personal skills criterion, education criterion strongly affects exam results criterion and education criterion very strongly affects technical skills and requirements criterion.

Table 1 Initial direct relation matrix of the case

	Cr1	Cr2	Cr3	Cr4	Cr5	Cr6	Cr7
1-Education (Cr1)	0	1	2	4	3	0	3
2-Experience (Cr2)	1	0	2	4	3	1	3
3-Personality and Personal Skills (Cr3)	2	2	0	3	1	3	2
4-Technical Skills and Requirements (Cr4)	3	3	3	0	0	0	4
5-Foreign Language (Cr5)	3	0	1	1	0	3	2
6-Vocational Flexibility (Cr6)	0	0	1	0	0	0	0
7-Exam Results (Cr7)	3	3	2	3	2	0	0

This initial direct relation matrix is normalized regarding DEMATEL steps and normalized matrix is shown in Table 2.

Table 2 Normalized direct relation matrix of the case

	Cr1	Cr2	Cr3	Cr4	Cr5	Cr6	Cr7
1-Education (Cr1)	0.000	0.067	0.133	0.267	0.200	0.000	0.200
2-Experience (Cr2)	0.067	0.000	0.133	0.267	0.200	0.067	0.200
3-Personality and Personal Skills (Cr3)	0.133	0.133	0.000	0.200	0.067	0.200	0.133
4-Technical Skills and Requirements (Cr4)	0.200	0.200	0.200	0.000	0.000	0.000	0.267
5-Foreign Language (Cr5)	0.200	0.000	0.067	0.067	0.000	0.200	0.133
6-Vocational Flexibility (Cr6)	0.000	0.000	0.067	0.000	0.000	0.000	0.000
7-Exam Results (Cr7)	0.200	0.200	0.133	0.200	0.133	0.000	0.000

After the normalized matrix, the total relation matrix T is calculated and shown in Table 3.

Table 3 Total relation matrix

	Cr1	Cr2	Cr3	Cr4	Cr5	Cr6	Cr7
1-Education (Cr1)	0.572	0.528	0.622	0.886	0.570	0.274	0.815
2-Experience (Cr2)	0.637	0.468	0.628	0.889	0.572	0.338	0.818
3-Personality and Personal Skills (Cr3)	0.586	0.511	0.436	0.739	0.403	0.402	0.662
4-Technical Skills and Requirements (Cr4)	0.756	0.671	0.706	0.732	0.453	0.276	0.902
5-Foreign Language (Cr5)	0.510	0.276	0.371	0.467	0.248	0.342	0.498
6-Vocational Flexibility (Cr6)	0.039	0.034	0.096	0.049	0.027	0.027	0.044
7-Exam Results (Cr7)	0.739	0.638	0.632	0.862	0.539	0.277	0.662

Normalized initial direct relation matrix is multiplied by the matrix which is obtained by subtracting normalized initial direct relation matrix from identity matrix and that result is inverted. The row and column sums are calculated and shown in Table 4.

Each row and column are summed. In addition, row and column sums are also added up and column sums are subtracted from the row sums. These ri+cj and ri-cj values show the impact relations in DEMATEL method.

Threshold value is calculated as by diving sum of all elements to number of elements and obtained as α= 0.494. Numbers which are bigger than the threshold value are in bold as indicated in Table 5. However, there are two exceptions including 0.402 and 0.096. Since there are no selected values in the row and column "Cr6", these values which are the biggest ones in their rows and columns are chosen as proposed by Wu et al. (2011). Hence in case there are no values bigger than the threshold value in any row or column, the biggest one in the related row or column is chosen so as to utilize the related row or column (Wu et al., 2011).

Table 5 The values that are used in 'Network Relationship Map'

	Cr1	Cr2	Cr3	Cr4	Cr5	Cr6	Cr7
Cr1	**0.572**	**0.528**	**0.622**	**0.886**	**0.570**	0.274	**0.815**
Cr2	**0.637**	0.468	**0.628**	**0.889**	**0.572**	0.338	**0.818**
Cr3	**0.586**	**0.511**	0.436	**0.739**	0.403	**0.402***	**0.662**
Cr4	**0.756**	**0.671**	**0.706**	**0.732**	0.453	0.276	**0.902**
Cr5	**0.510**	0.276	0.371	0.467	0.248	0.342	**0.498**
Cr6	0.039	0.034	**0.096***	0.049	0.027	0.027	0.044
Cr7	**0.739**	**0.638**	**0.632**	**0.862**	**0.539**	0.277	**0.662**

The related NRM is obtained with respect to bold values which are depicted in Figure 2.

Table 4 Row and column sums of total relation matrix

	Cr1	Cr2	Cr3	Cr4	Cr5	Cr6	Cr7	r_i	c_j	$r_i + c_j$	$r_i - c_j$
Cr1	0.572	0.528	0.622	0.886	0.570	0.274	0.815	4.267	3.841	8.108	0.426
Cr2	0.637	0.468	0.628	0.889	0.572	0.338	0.818	4.349	3.126	7.475	1.223
Cr3	0.586	0.511	0.436	0.739	0.403	0.402	0.662	3.739	3.490	7.229	0.249
Cr4	0.756	0.671	0.706	0.732	0.453	0.276	0.902	4.497	4.624	9.121	-0.126
Cr5	0.510	0.276	0.371	0.467	0.248	0.342	0.498	2.712	2.813	5.525	-0.101
Cr6	0.039	0.034	0.096	0.049	0.027	0.027	0.044	0.316	1.936	2.252	-1.620
Cr7	0.739	0.638	0.632	0.862	0.539	0.277	0.662	4.349	4.400	8.750	-0.051

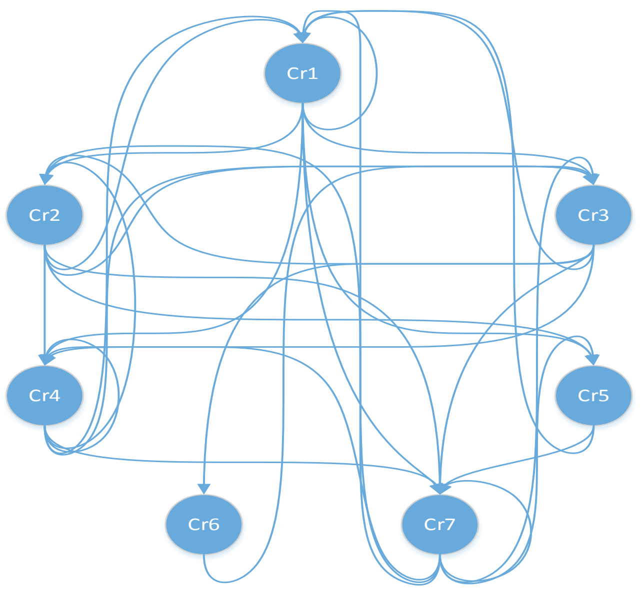

Figure 2 Network relation model of the whole case

4.3 ANP Stage

After obtaining the network relation map as a result of DEMATEL method, ANP technique is utilized considering this map. The pairwise comparisons are performed by the human resource expert and the eigenvectors are obtained. For clarifying this process, it is focused on one of the criteria and the related operations are explained. The considered criterion is the third criterion which is "Personality and Personal Skills". Regarding the network relation map, it is seen that the third criterion affects "Education", "Experience", "Technical Skills and Requirements", Vocational Flexibility" and "Exam Results". Hence, the pairwise comparison is performed between these five criteria with respect to "Personality and Personal Skills" as indicated in Table 6.

Table 6 The pairwise comparisons with respect to "Personality and Personal Skills"

	Cr1	Cr2	Cr4	Cr6	Cr7
Education (Cr1)	1	2	1	1	1
Experience (Cr2)	½	1	1	1	2
Technical Skills and Requirements (Cr4)	1	1	1	2	3
Vocational Flexibility (Cr6)	1	1	1/2	1	3
Exam Results (Cr7)	1	1/2	1/3	1/3	1

After performing the required steps in ANP, the eigenvector is obtained as [0.224, 0.188, 0.269, 0.205, 0.111] with a consistency ratio of 0.065 which is under 0.10. The similar steps are performed for the other pairwise comparisons and shown in Appendix (Table 13). Finally, the limit matrix is formed as shown in Table 7. Hence, these values will be used as criteria importance weights in the ELECTRE method.

Table 7 The limit matrix of the case

	Cr1	Cr2	Cr3	Cr4	Cr5	Cr6	Cr7
Cr1	0.2933	0.2933	0.2933	0.2933	0.2933	0.2933	0.2933
Cr2	0.2015	0.2015	0.2015	0.2015	0.2015	0.2015	0.2015
Cr3	0.1669	0.1669	0.1669	0.1669	0.1669	0.1669	0.1669
Cr4	0.1499	0.1499	0.1499	0.1499	0.1499	0.1499	0.1499
Cr5	0.0553	0.0553	0.0553	0.0553	0.0553	0.0553	0.0553
Cr6	0.0343	0.0343	0.0343	0.0343	0.0343	0.0343	0.0343
Cr7	0.0990	0.0990	0.0990	0.0990	0.0990	0.0990	0.0990

4.4 ELECTRE Stage

Having the criteria importance weights as a result of the ANP method, the steps of ELECTRE method are executed to get the ranking of the candidates. The scorings of the seven candidates (Cnd1,…,Cnd7) with respect to the seven criteria are depicted in Table 8.

Table 8 ELECTRE decision matrix of the case

	Education	Personality and Personal Skills	Experience	Technical Skills and Requirements	Foreign Language	Vocational Flexibility	Exam Results
Cnd1	100	100	100	80	85	100	100
Cnd2	97	100	80	80	85	100	100
Cnd3	97	100	80	70	75	100	95
Cnd4	97	100	90	85	80	100	80
Cnd5	100	100	80	70	65	100	10
Cnd6	100	100	80	75	70	100	15
Cnd7	100	100	50	70	50	100	20

Using Equation 12 in 'Methods' Part, initial matrix is normalized. An example for normalization calculation of one of the matrix elements (x11) is shown as follows:

$$x_{11} = \frac{100}{\sqrt{100^2+97^2+97^2+97^2+100^2+100^2+100^2}} = 0.383$$

Normalized ELECTRE decision matrix is given in Table 9

Table 9 Normalized ELECTRE decision matrix of the case

	Education	Personality and Personal Skills	Experience	Technical Skills and Requirements	Foreign Language	Vocational Flexibility	Exam Results
Cnd1	0.383	0.378	0.465	0.398	0.435	0.378	0.526
Cnd2	0.371	0.378	0.372	0.398	0.435	0.378	0.526
Cnd3	0.371	0.378	0.372	0.348	0.384	0.378	0.500

Cnd4	0.371	0.378	0.419	0.423	0.410	0.378	0.421
Cnd5	0.383	0.378	0.372	0.348	0.333	0.378	0.053
Cnd6	0.383	0.378	0.372	0.373	0.359	0.378	0.079
Cnd7	0.383	0.378	0.233	0.348	0.256	0.378	0.105

Afterwards, each value in the normalized ELECTRE decision matrix is multiplied by the related criterion importance weight and the weighted decision matrix of the case is obtained and shown in Table 10. The first element x11 (0.112) is obtained by multiplying 0.383 by the importance weight of the first criterion which is 0.293.

Table 10 Weighted decision matrix of the case

	Education	Personality and Personal Skills	Experience	Technical Skills and Requirements	Foreign Language	Vocational Flexibility	Exam Results
Cnd1	0.112	0.076	0.078	0.060	0.024	0.013	0.052
Cnd2	0.109	0.076	0.062	0.060	0.024	0.013	0.052
Cnd3	0.109	0.076	0.062	0.052	0.021	0.013	0.049
Cnd4	0.109	0.076	0.070	0.063	0.023	0.013	0.042
Cnd5	0.112	0.076	0.062	0.052	0.018	0.013	0.005
Cnd6	0.112	0.076	0.062	0.056	0.020	0.013	0.008
Cnd7	0.112	0.076	0.039	0.052	0.014	0.013	0.010

As explained in the methodology part, the concordance and discordance indexes are obtained and shown in Appendix (Table 14). Regarding the outranking relations, the graph is drawn as in Figure 3.

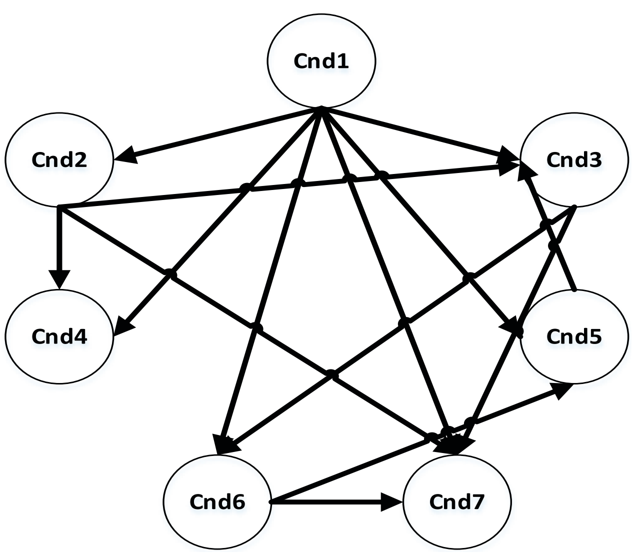

Figure 3 The outranking relations of candidates

Considering the graph, the best candidate is clear and it is candidate 1. However, a complete ranking is not obtained. Hence, the net concordance and discordance indexes are calculated and average rankings are used to clarify the final ranking. Moreover, for the clarification of steps, the operations for finding C1 and D1 are clearly provided as follows:

C1 = (C12 + C13 + C14 + C15 + C16 + C17) – (C21 + C31 + C41 + C51 + C61 + C71)

(1+1+0.85+1+1+1) – (0.540+0.236+0.385+0.529+0.529 +0.529) = 3.103

D1 = (D12 + D13 + D14 + D15 + D16 + D17) – (D21 + D31 + D41 + D51 + D61 + D71) = 3.103

(0+0+0.358+0+0+0) – (1+1+1+1+1+1) = – 5.642

All of the net concordance (Net Cp) and discordance (Net Dp) values of the candidates are obtained and indicated in Table 11 with the average rankings.

Table 11 Net concordance and discordance values of candidates

Candidate	Net Cp Value	Cp Rank	Net Dp Value	Dp Rank	Average of Cp and Dp Ranks	Final Rank
1	3,1032	1	-5,6419	1	1	1
2	-0,1192	4	-3,0262	2	3	3
3	-1,741	7	-0,4462	4	5.5	6
4	0,5026	2	-2,1054	3	2.5	2
5	-0,7026	5	3,9833	6	5.5	5
6	0,2058	3	1,8467	5	4	4
7	-1,2488	6	5,3897	7	6.5	7

Regarding the average of ranking values, the candidates from best to worst can be listed. However, there is a tie between Cnd3 and Cnd5 and this tie is broken considering the outranking relation between these candidates. Hence, the final ranking is determined as Cnd1, Cnd4, Cnd2, Cnd6, Cnd5, Cnd3 and Cnd7. Moreover, sensitivity analysis is performed for the "education" and "experience" which are the two most important criteria having half of the total criteria importance weight. As seen in Figures 4 and 5, it is observed that the winner "Candidate 1" does not change.

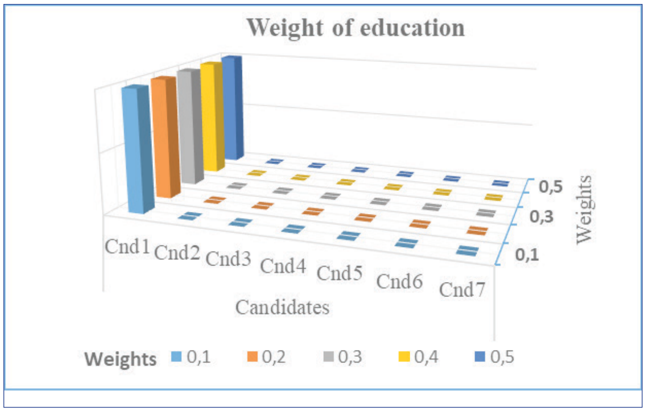

Figure 4 Sensitivity analysis on the weight of "education"

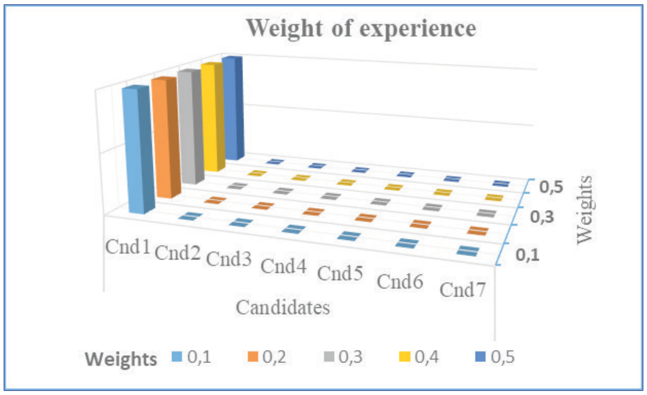

Figure 5 Sensitivity analysis on the weight of "experience"

V. CONCLUSION

Personnel selection is one of the touchstones of an organization. False selections can lead to capital loss, time loss, lower productivity, more injuries at work. Therefore, finding the best candidates for a company is a very critical issue.

This paper proposes a new methodology that combines three distinct tools; DEMATEL, ANP and ELECTRE. Firstly, DEMATEL method is utilized to find out the predetermined personnel selection criteria (determined by literature review and expert opinions) relations and criteria relation map is developed. Secondly, ANP technique is used to determine the importance weights of the criteria. Finally, the applicants are ranked by ELECTRE tool. Developed methodology is implemented in a firm in automotive industry to gain validity. In addition, this methodology isn't sector-specific. Although, this methodology is only applied in automotive sector, it can be generalized and applied to all sectors including various decision making problems such as supplier selection, project selection and software selection. Moreover, with the application of the proposed methodology, a systematic approach will be provided for the real life decision making problems. Thus, this paper contributes to the literature by introducing a new methodology and applying it in industry for personnel selection problem. In this new methodology, different decision problems and different sectors can be used for implementation for future studies of this subject. Moreover, the proposed integrated methodology can be enhanced with fuzzy approaches.

APPENDIX

See Tables 12, 13 and 14

Table 12 Literature review table about personnel selection

AUTHORS (YEAR)	SOLUTION METHOD	JOB POSITION
Yaakob and Kawata (1999)	Fuzzy number approach with linguistic variables	Worker
Tsao and Chu (2001)	Fuzzy set theory with multi-criteria approach	Industrial engineer
Seol and Sarkis (2005)	AHP	Internal auditor
Dağdeviren and Yüksel (2007)	ANP	Unstated
Wu and Lee (2007)	FDEMATEL	Global manager
Zavadskas et al. (2008)	COPRAS-G (COmplex Proportional ASsessment of alternatives with grey relations)	Project manager
Ayub et al. (2009)	FANP	Post lecturer
Saremi et al. (2009)	FTOPSIS	TQM Consultant
Wang (2009)	TOPSIS	R&D personnel
Afshari et al. (2010)	AHP, ELECTRE	Unstated
Aksakal and Dağdeviren (2010)	ANP and DEMATEL	Industrial engineer
Chen and Lee (2010)	Interval type 2 FTOPSIS	System analysis engineer
Dursun and Karsak (2010)	2-tuple linguistic representation model with TOPSIS	Industrial engineer
Kelemenis and Askounis (2010)	FTOPSIS	CIO
Akhlaghi (2011)	Rough set exploration system	Construction project manager
Kelemenis et al. (2011)	FTOPSIS with veto threshold	Middle level manager
Keršulienė and Turskis (2011)	ARAS-F and SWARA	Architect
Shahhosseini and Sebt (2011)	Adaptive Neuro-Fuzzy Inference System and FAHP	Project manager, technician, engineer, laborer
Zhang and Liu (2011)	Intuitionistic fuzzy multi-criteria group decision making method with GRA	System Analysis Engineer
Baležentis et al. (2012)	Fuzzy MULTIMOORA with linguistic reasoning and group decision-making	Unstated
Gilan et al. (2012)	Computing with words (CWW)	Project Management Engineer
Kabak and Kazançoğlu (2012)	FAHP	Academic personnel
Roy et al. (2012)	DEMATEL and AHP	Unstated
Aksakal et al. (2013)	DEMATEL and TOPSIS	General Manager
Fathi et al. (2013)	Logarithmic fuzzy preference programming and TOPSIS methods	Human resources manager
Kumar et al. (2013)	SAW, WPM, AHP and TOPSIS	Asst. Prof.
Ozdemir (2013)	AHP with stochastic dynamic programming	Marketing Dept.
Rouyendegh and Erkan (2013)	Fuzzy ELECTRE	Academic personnel
Yu et al. (2013)	GHFPWA and GHFPWG, hesitant fuzzy sets	Sales engineer
Bogdanovic and Miletic (2014)	AHP and PROMETHEE	Employee (Informatics department)
Doğan and Önder (2014)	AHP and TOPSIS	Sales consultant
Eroglu et al. (2014)	ORESTE	Accountant officer, marketing officer
Keršulienė and Turskis (2014)	ARAS-F and AHP	Chief accountant officer
Saad et al. (2014)	Hamming distance method with subjective and objective weights (HDMSOW's)	Lecturer
Safari et al. (2014)	TOPSIS and Hungary assignment algorithm	Unstated
Yıldız and Aksoy (2015)	AHP	A group of engineers
Erdem (2016)	FAHP	Junior developer
Khandekar and Chakraborty (2016)	Fuzzy axiomatic design	Deputy Manager (Middle)
Özder et al. (2016)	ANP and PROMETHEE	Academic staff

Table 13 ANP pairwise comparisons

Pairwise comparison matrix with respect to "Education" (C.R.: 0.067)

	1	2	3	4	5	7	Weight
1	1	1	3	3	3	5	0.2857
2	1	1	4	4	4	5	0.3379
3	1/3	1/4	1	1	5	4	0.1556
4	1/3	1/4	1	1	1	3	0.0994
5	1/3	1/4	1/5	1	1	3	0.0800
7	1/5	1/5	1/4	1/3	1/3	1	0.0412

Pairwise comparison matrix with respect to "Experience" (C.R.: 0.095)

	1	3	4	5	7	Weight
1	1	2	1	7	2	0.3523
3	½	1	2	1	1	0.1907
4	1	1/2	1	2	2	0.2118
5	1/7	1	½	1	½	0.0952
7	1/2	1	1/2	2	1	0.1498

Pairwise comparison matrix with respect to "Personality and Personal Skills" (C.R.: 0.065)

	1	2	4	6	7	Weight
1	1	2	1	1	1	0.2246
2	½	1	1	1	2	0.1887
4	1	1	1	2	3	0.2698
6	1	1	1/2	1	3	0.2055
7	1	1/2	1/3	1/3	1	0.1112

Pairwise comparison matrix with respect to "Technical Skills and Requirements" (C.R.: 0.078)

	1	2	3	4	7	Weight
1	1	1	2	3	1	0.2685
2	1	1	2	2	4	0.3087
3	1/2	½	1	2	2	0.1785
4	1/3	1/2	½	1	2	0.1293
7	1	1/4	1/2	1/2	1	0.1148

Pairwise comparison matrix with respect to "Foreign Language" (C.R.: 0)-

	1	7	Weight
1	1	3	0.7500
7	1/3	1	0.2500

Pairwise comparison matrix with respect to "Exam Results" (C.R.: 0.095)

	1	2	3	4	5	7	Weight
1	1	1	1	1	1	5	0.1954
2	1	1	3	1	2	2	0.2482
3	1	1/3	1	4	2	2	0.2192
4	1	1	1/4	1	1	2	0.1376
5	1	½	1/2	1	1	2	0.1271
7	1/5	1/2	1/2	1/2	½	1	0.0723

Table 14 Concordance and discordance indexes for personnel selection case

C(p,q)	Concordance index	C(p,q)>=Cavg	D(p,q)	Discordance index	D(p,q) < Davg	CNDp >> CNDq
C(1,2)	1.000	YES	D(1,2)	0.000	YES	CND1 >>CND2
C(1,3)	1.000	YES	D(1,3)	0.000	YES	CND1>> CND3
C(1,4)	0.850	YES	D(1,4)	0.358	YES	CND1 >>CND4
C(1,5)	1.000	YES	D(1,5)	0.000	YES	CND1 >>CND5
C(1,6)	1.000	YES	D(1,6)	0.000	YES	CND1 >>CND6
C(1,7)	1.000	YES	D(1,7)	0.000	YES	CND1 >>CND7
C(2,1)	0.540	NO	D(2,1)	1.000	NO	NO
C(2,3)	1.000	YES	D(2,3)	0.000	YES	CND2 >>CND3
C(2,4)	0.683	YES	D(2,4)	0.745	YES	CND2 >>CND4
C(2,5)	0.706	NO	D(2,5)	0.072	YES	NO
C(2,6)	0.706	NO	D(2,6)	0.076	YES	NO
C(2,7)	0.706	YES	D(2,7)	0.081	YES	CND2 >>CND7
C(3,1)	0.236	YES	D(3,1)	1.000	NO	NO
C(3,2)	0.696	NO	D(3,2)	1.000	NO	NO
C(3,4)	0.628	NO	D(3,4)	1.000	NO	NO
C(3,5)	0.706	NO	D(3,5)	0.076	YES	NO
C(3,6)	0.557	YES	D(3,6)	0.090	YES	CND3 >>CND6
C(3,7)	0.706	YES	D(3,7)	0.086	YES	CND3 >>CND7
C(4,1)	0.385	NO	D(4,1)	1.000	NO	NO
C(4,2)	0.845	YES	D(4,2)	1.000	NO	NO

C(4,3)	0.900	YES	D(4.2)	0.698	NO	NO
C(4,5)	0.706	NO	D(4,5)	0.092	YES	NO
C(4,6)	0.706	NO	D(4,6)	0.100	YES	NO
C(4,7)	0.706	NO	D(4,7)	0.108	YES	NO
C(5,1)	0.529	NO	D(5,1)	1.000	YES	NO
C(5,2)	0.696	NO	D(5,2)	1.000	NO	NO
C(5,3)	0.845	YES	D(5,3)	1.000	YES	CND5>>CND3
C(5,4)	0.529	NO	D(5,4)	1.000	NO	NO
C(5,6)	0.696	NO	D(5,6)	1.000	NO	NO
C(5,7)	0.900	YES	D(5,7)	0.224	NO	NO
C(6,1)	0.529	NO	D(6,1)	1.000	NO	NO
C(6,2)	0.696	NO	D(6,2)	1.000	NO	NO
C(6,3)	0.845	YES	D(6,3)	1.000	NO	NO
C(6,4)	0.529	NO	D(6,4)	1.000	NO	NO
C(6,5)	1.000	YES	D(6,5)	0.000	YES	CND6 >>CND5
C(6,7)	0.900	YES	D(6,7)	0.112	YES	CND6 >>CND7
C(7,1)	0.529	NO	D(7,1)	1.000	NO	NO
C(7,2)	0.529	NO	D(7,2)	1.000	NO	NO
C(7,3)	0.679	NO	D(7,3)	1.000	NO	NO
C(7,4)	0.529	NO	D(7,4)	1.000	NO	NO
C(7,5)	0.778	YES	D(7,5)	1.000	NO	NO
C(7,6)	0.628	NO	D(7,6)	1.000	NO	NO
Cavg	0.722		Davg	0.569		

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