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PERSONNEL SELECTION USING ANALYTIC NETWORK PROCESS

Metin DAĞDEVİREN* , İhsan YÜKSEL**

ABSTRACT

In literature, there are various methods regarding personnel selection. However, it is observed that in these methods, the interdependency of personnel selection factors are not taken into consideration. In this paper, a method including interdependencies of the personnel selection factors is studied for the purpose of satisfying the defect noticed. Firstly, the factors eligible to be accepted as criteria in personnel selection are determined, and a decision-making model demonstrating the dependency between these factors is developed. Global weights of the factors in the model are estimated by means of Analytic Network Process (ANP). Secondly, an evaluation scale as to the assessment of personnel selection factors is formed. Lastly, the way the adequacies of applicants can be measured is depicted with an example.

Keywords: Personnel Selection, Multiple Criteria Analysis, Analytic Network Process, Analytic Hierarchy Process

ANALİTİK AĞ SÜRECİ İLE PERSONEL SEÇİMİ

ÖZET

Literatürde personel seçimi problemi için kullanılan farklı metotlar bulunmaktadır Ancak, bu yöntemlerde personel seçim faktörlerinin karşılıklı bağımlılığı dikkate alınmamaktadır. Bu çalışmada yöntemlerin bu eksiliğinin giderilmesi amacıyla faktörler arasındaki bağımlılıkları da dikkate alan bir yöntem çalışması yapılmıştır. İlk olarak, personel seçimi probleminde kullanılacak faktörler belirlenmiş ve bu faktörler arasındaki bağımlılıklar belirlenerek bir karar verme modeli geliştirilmiştir. Bu modelde yer alan faktörlerin global ağırlıkları Analitik Ağ Süreciyle belirlenmiş ve bu ağırlıklar kullanılarak faktörler temelinde geliştirilen skalalar ile bir personel seçimi algoritması önerilmiştir. Çalışmada son olarak örnek bir çalışma üzerinde adayların yeterlilik düzeylerinin nasıl belirleneceği gösterilmiştir.

Anahtar Kelimeler: Personel Seçimi, Çok Kriterli Analiz, Analitik Ağ Süreci, Analitik Hiyerarşi Süreci

* *Gazi Üniversitesi, Endüstri Mühendisliği Bölümü, Maltepe, Ankara*
** *Kırıkkale Üniversitesi, İşletme Bölümü, Kırıkkale*

1. INTRODUCTION

Personnel selection is one of the chief phases of human resources management process. Basic function of personnel selection operations is determining, among the candidates applying for specific jobs in the company, the ones having the necessary knowledge, skill, and ability in order to be able to perform the requirements of the job successfully (Kaynak, 2002). Impartiality in personnel selection depends on fulfillment of two conditions, first of which is the necessity of specifying the criteria that can properly value the qualities of the personnel needed. At this stage, the factors which are qualified to become the criteria are established. Second condition is to assess and evaluate the knowledge, skills, and abilities of an applicant in the frame of the criteria established.

In literature, techniques applied in personnel selection, assessment and evaluation are written and oral exams (Arvey and Campion, 1982). Although evaluating applicants with written and oral exams is essential for the company when employing the personnel needed, it is not sufficient alone. In personnel selection, first of all, criteria (factors) that are to be the basis of assessment and evaluation must be specified; also the weights of these criteria must be determined. For each criterion has a different importance, or weight in personnel assessment and evaluation. Therefore, unsatisfactory selections may occur with assessment and evaluation tools, such as written or oral exams and tests which are not based upon certain criteria and weights.

In literature, there exist numerous studies conducted with the aim of performing personnel selection within the boundaries of objective criteria. Gargano et al. (1991) combined genetic algorithm and artificial neural networks for the purpose of selecting the personnel to be employed in finance sector. In this study, fundamental criteria were personality, social responsibility, education level, economics knowledge, finance knowledge, and experience factors. On the other hand, Miller and Feinzig (1993) suggested the fuzzy sets theory for the personnel selection problem. Liang and Wang (1994) developed an algorithm which also uses the fuzzy sets theory. In this algorithm, subjective criteria, such as personality, leadership, and past experience, along with some objective criteria, such as general aptitude, and comprehension were made use of. Karsak (2001) modeled personnel selection process by using fuzzy multiple criteria programming and evaluated qualitative and quantitative factors together via membership functions in this model. Capaldo and Zollo (2001) built up a model to improve the effectiveness of personnel selection processes in major Italian companies. First step of the study developed decision formulations and decision samples to be used on the basis of the evaluation method adopted by the companies. Second step was to build an evaluation method by utilizing fuzzy logic. Personnel selection factors taken into consideration were classified in three groups, each one of which being professional skills, managerial skills, and personal characteristics. Multi-criteria analyses are other personnel selection methods reported in literature (Bohanec et al.1992; Timmermans and Vlek 1992,1996; Gardiner and Armstrong-Wright 2000; Spyridakos et al. 2001; Jessop

2004). These methods can be effectively employed while evaluating a multitude of factors together in the solution of especially large and complicated problems. Roth and Babko (1997) reviewed some of the issues surrounding the use of multi-attribute methods in human resources management. Hooper et al. (1998), however, developed an expert system named BOARDEX. American army has used this system to employ its personnel. Personnel selection factors, such as grade, military education level, civilian education level, height, weight, and assignment history are incorporated in this expert system.

Some conclusions have been drawn, after examining the studies in literature relating to personnel selection. First of the inferences is that, objectivity in personnel selection decisions is striven to be attained via the studies performed. A second common feature observed is that, not only are there similar selection criteria (factors) in developed or suggested personnel selection models, but various criteria are also used. Another shared characteristic observed in existing studies is, possible interdependencies between the factors included in the personnel selection model being neglected. It is not possible to assume that each criterion to be incorporated in personnel selection model is independent. Any factor in the model could be related to, or dependent on another. Thus, weights of the factors alone in the personnel selection model are important; besides, weights that are to be determined as a result of mutual interactions of the factors are also substantial. In personnel selection model, evaluating the interdependencies between factors should contribute to the objectivity of decisions.

In the based on preceding literature research, developing a personnel selection model is attempted by using the ANP method which includes interdependencies between factors. Additionally, an evaluation scale based on personnel selection factor weights, which the model embeds, is formed. Also, an applicant competence inspection application is performed by means of factor weights and evaluation scales.

2. ANALYTIC NETWORK PROCESS

Studies in literature identify the multi-criteria decision technique known as the Analytic Hierarchy Process (AHP) to be most appropriate for solving complicated problems. AHP was proposed by Saaty (1980) in 1980 as a method of solving socio-economic decision making problems and has been used to solve a wide range of problems.

The AHP is a comprehensive framework that is designed to cope with the intuitive, the rational, and the irrational when we make multi-objective, multi-criterion, and multi-actor decisions with and without certainty of any number of alternatives. The basic assumptions of AHP are that it can be used in functional independence of an upper part or cluster of the hierarchy from all its lower parts and the criteria or items in each level.

Many decision problems cannot be structured hierarchically because they involve the interaction and dependence of higher level elements on a lower level element (Saaty, 1996). Structuring a problem involving functional dependence allows for feedback among clusters. This is a network system. Saaty (1996) suggested the use of AHP to solve the problem of independence on alternatives or criteria, and the use of ANP to solve the problem of dependence among alternatives or criteria.

The ANP also introduced by Saaty, is a generalization of the AHP (Saaty, 1996). Whereas AHP represents a framework with a uni-directional hierarchical relationship. ANP allows for complex interrelationships among decision levels and attributes. The ANP feedback approach replaces hierarchies with networks in which the relationships between levels are not easily represented as higher or lower, dominated or being dominated, directly or indirectly (Meade and Sarkis, 1999). For instance, not only does the importance of the criteria determine the importance of the alternatives as in a hierarchy, but also the importance of the alternatives may have impact on the importance of the criteria (Saaty, 1996). Therefore, a hierarchical structure with a linear top-to-bottom form is not applicable for a complex system.

A system with feedback can be represented by a network where nodes correspond to the levels or components (Saaty, 1980). The structural difference between a hierarchy and a network is depicted in Figure 1. The elements in a node (or level) may influence some or all the elements of any other node. In a network, there can be source nodes, intermediate nodes and sink nodes. Relationships in a network are represented by arcs, and the directions of arcs signify dependence (Saaty, 1996). Interdependency between two nodes, termed outer dependence, is represented by a two-way arrow, and inner dependencies among elements in a node are represented by a looped arc (Sarkis, 2002/a).

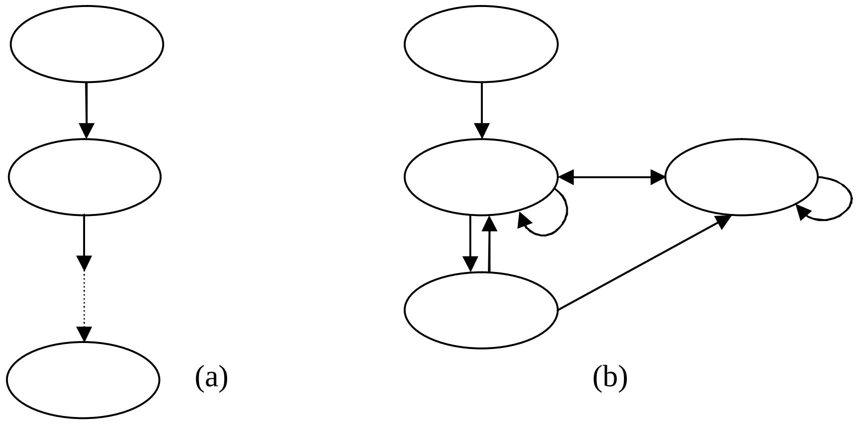

Figure 1. Structural Difference Between a Hierarchy and a Network (a) a Hierarchy (b) a Network (Chung et. al., 2006)

The process of ANP comprises four major steps (Chung et al, 2006):

Step 1: Model construction and problem structuring: The problem should be stated clearly and decomposed into a rational system like a network. The structure can be obtained by the opinion of decision makers through brainstorming or other appropriate methods. An example of the format of a network is as shown in Figure 1(b).

Step 2: Pairwise comparisons matrices and priority vectors: In ANP, like AHP, decision elements at each component are compared Pairwise with respect to their importance towards their control criterion, and the components themselves are also compared pairwise with respect to their contribution to the goal. Decision makers are asked to respond to a series of pairwise comparisons where two elements or two components at a time will be compared in terms of how they contribute to their particular upper level criterion (Meade and Sarkis, 1999). In addition, if there are interdependencies among elements of a component, pairwise comparisons also need to be created, and an eigenvector can be obtained for each element to show the influence of other elements on it. The relative importance values are determined with Saaty's 1-9 scale (Table 1), where a score of 1 represents equal importance between the two elements and a score of 9 indicates the extreme importance of one element (row component in the matrix) compared to the other one (column component in the matrix) (Meade and Sarkis, 1999).

Table 1. Saaty's 1-9 Scale for AHP Preference (Yurdakul, 2003; Cheng and Li, 2001)

Intensity of importance	Definition	Explanation
1	Equal importance	two activities contribute equally to the objective
3	Moderate importance	experience and judgement slightly favour one over another
5	Strong importance	experience and judgment strongly favour one over another
7	Very strong importance	activity is strongly favoured and its dominance is demonstrated in practice
9	Absolute importance	importance of one over another affirmed on the highest possible order
2,4,6,8	Intermediate values	Used to represent compromise between the priorities listed above
Reciprocal of above non-zero Numbers	if activity *i* has one of the above non-zero numbers assigned to it when compared with activity *j*, then *j* has the reciprocal value when compared with *i*	

A reciprocal value is assigned to the inverse comparison; that is, $a_{ij}=1/a_{ji}$, where a_{ij} (a_{ji}) denotes the importance of the *i*th (*j*th) element. Like AHP, pairwise comparison in ANP is made in the framework of a matrix, and a local priority vector can be derived as an estimate of relative importance associated with the elements (or components) being compared by solving the following equation:

$$A\times w = \lambda_{max}\times w \tag{1}$$

where A is the matrix of pairwise comparison, w is the eigenvector, and λ_{max} is the largest eigenvalue of A. Saaty (1980) proposes several algorithms for approximating w. In this paper, the following three-step procedure is used to synthesize priorities (Chung et al., 2006).

1. Sum the values in each column of the pairwise comparison matrix.
2. Divide each element in a column by the sum of its respective column. The resultant matrix is referred to as the normalized pairwise comparison matrix.
3. Sum the elements in each row of the normalized pairwise comparison matrix, and divide the sum by the n elements in the row. These final numbers provide an estimate of the relative priorities for the elements being compared with respect to its upper level criterion.

Priority vectors must be derived for all comparison matrices.

Step 3: Supermatrix formation*:* The supermatrix concept is similar to the Markov chain process (Saaty, 1996). To obtain global priorities in a system with interdependent influences, the local priority vectors are entered in the appropriate columns of a matrix. As a result, a supermatrix is actually a partitioned matrix, where each matrix segment represents a relationship between two nodes (components or clusters) in a system (Meade and Sarkis, 1999). Let the components of a decision system be C_k, k=1,2,…,n, and each component k has m_k elements, denoted by $e_{k1}, e_{k2},\ldots,e_{kmk}$. The local priority vectors obtained in Step 2 are grouped and located in appropriate positions in a supermatrix based on the flow of influence from a component to another component, or from a component to itself as in the loop. A standard form of a supermatrix is as in (2) (Saaty, 1996).

$$
\begin{array}{ccc}
 & & \begin{array}{cccccccccccccc} & C_1 & & & & C_k & & & & & C_n & & \\ e_{11} & e_{12} & \cdots & e_{1\,m1} & \cdots & e_{k1} & e_{k2} & \cdots & e_{k\,\mathrm{mk}} & \cdots & e_{n1} & e_{n2} & \cdots & e_{n\,\mathrm{mn}} \end{array} \\
\mathbf{W} = & \begin{array}{cc} C_1 & \begin{array}{c} e_{11} \\ e_{12} \\ \vdots \\ e_{1\,m1} \end{array} \\ \vdots & \vdots \\ C_k & \begin{array}{c} e_{k1} \\ e_{k2} \\ \vdots \\ e_{k\,\mathrm{mk}} \end{array} \\ \vdots & \vdots \\ C_n & \begin{array}{c} e_{n1} \\ e_{n2} \\ \vdots \\ e_{n\,\mathrm{mn}} \end{array} \end{array} & \begin{bmatrix} W_{11} & \cdots & W_{1k} & \cdots & W_{1n} \\ \vdots & & \vdots & \vdots & \vdots \\ W_{k1} & \cdots & W_{kk} & \cdots & W_{kn} \\ \vdots & & & \vdots & \\ W_{n1} & \cdots & W_{nk} & \cdots & W_{nn} \end{bmatrix}
\end{array}
\tag{2}$$

As an example, the supermatrix representation of a hierarchy with three levels as shown in Figure 2(a), is follows (Saaty, 1996).

$$\mathbf{W_h} = \begin{bmatrix} 0 & 0 & 0 \\ w_{21} & 0 & 0 \\ 0 & W_{32} & I \end{bmatrix} \quad (3)$$

where w_{21} is a vector that represent the impact of the goal on the criteria, W_{32} is a matrix that represents the impact of criteria on each of the alternatives, I is the identity matrix, and entries of zeros corresponding to those elements that have no influence.

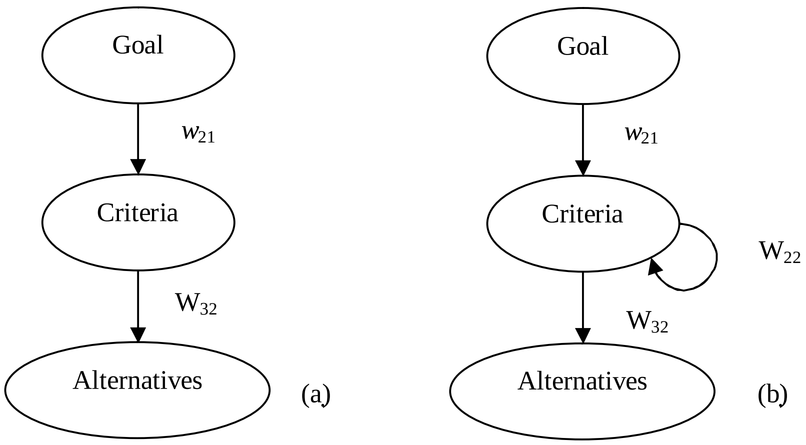

Figure 2. Hierarchy and Network
(a) a Hierarchy; (b) a Network (Chung et. al., 2006; Momoh and Zhu, 2003)

For the above example, if the criteria are interrelated among themselves, the hierarchy is replaced by a network as shown in Figure 2(b). The entry of W_n given by W_{22} would indicate the interdependency, and the supermatrix would be (Saaty, 1996).

$$\mathbf{W_n} = \begin{bmatrix} 0 & 0 & 0 \\ w_{21} & W_{22} & 0 \\ 0 & W_{32} & I \end{bmatrix} \quad (4)$$

Note that any zero in the supermatrix can be replaced by a matrix if there is an interrelationship of the elements in a component or between two components. Since there usually is interdependence among clusters in a network, the columns of a supermatrix usually sum to more than one. The supermatrix must be transformed first to make it stochastic, that is, each column of the matrix sums to unity. A recommended approach by Saaty (1996) is to determine the relative importance of the clusters in the supermatrix with the column cluster (block) as the controlling component (Meade and Sarkis, 1999). That is, the row components with nonzero entries for their blocks in that column block are compared according to their impact on the component of that column block (Saaty, 1996). With pairwise comparison matrix of the row components with respect to the column component, an eigenvector can be obtained. This process gives rise to an eigenvector for each column block. For each column block, the first entry of the respective eigenvector is multiplied by all the elements in the first block of that column, the second by all the elements in the second block of that column and so on. In this way, the blocks in each column of the supermatrix are weighted, and the result is known as the weighted supermatrix, which is stochastic.

Raising a matrix to powers gives the long-term relative influences of the elements on each other. To achieve a convergence on the importance weights, the weighted supermatrix is raised to the power of $2k+1$, where k is an arbitrarily large number, and this new matrix is called the limit supermatrix (Saaty, 1996). The limit supermatrix has the same form as the weighted supermatrix, but all the columns of the limit supermatrix are the same. By normalizing each block of this supermatrix, the final priorities of all the elements in the matrix can be obtained.

***Step 4: Selection of best alternatives**:* If the supermatrix formed in Step 3 covers the whole network, the priority weights of alternatives can be found in the column of alternatives in the normalized supermatrix. On the other hand, if a supermatrix only comprises of components that are interrelated, additional calculation must be made to obtain the overall priorities of the alternatives. The alternative with the largest overall priority should be the one selected.

Over the years, ANP, a comprehensive multi-purpose decision method, has been widely used in solving many complicated decision problems. Meade and Sarkis (1998, 1999) in two of their studies, used ANP in a methodology they developed to evaluate logistic strategies and to improve production speed. Also in two separate studies performed by Lee and Kim (2001/a, 2001/b) ANP is used in Interdependent Information System Project Selection process. And project priorities found in these two studies are taken as restraints in 0-1 Goal Programming model. Karsak et al. (2002) and Partovi and Corredoira (2002) used ANP in quality function deployment process. In addition to these studies Meade and Presley (2002), in evaluating alternative Research & Development projects; Bayazıt (2002), in determining the best production management system for a production company; Sarkis (2002/b), in a model he developed for the purpose of strategic supplier selection; Mikhailov and Singh (2003), in the development process of a decision support system; Yurdakul

(2003), in a model he built in order to evaluate long term performances of production systems; Momoh and Zhu (1998), in specifying optimal production schedules; Niemira and Saaty (2004), in Financial Crisis Forecasting; Chung et al. (2006), in a model they developed for product mixture, used ANP method.

3. A MODEL FOR PERSONNEL SELECTION

In this section, personnel selection problem is modeled with ANP method, and factors used in selection process are weighted according to this method. Study is carried out with the algorithm steps given below.

Algorithm:

Step 1: Establishing a personnel selection team and determining the factors.
Step 2: Grouping the designated factors according to subjective, objective and 0-1 categories.
Step 3: Determining interdependencies between factors and setting up the ANP model.
Step 4: Bearing in mind the interdependencies determined in Step 3, constituting comparison matrices with respect to quantitative and qualitative factors, and creating priority vectors.
Step 5: Forming the initial supermatrix by using priority vectors, and estimating the weights corresponding to quantitative and qualitative factors by taking this matrix as a starting point.
Step 6: Weighting the factors in 0-1 factor group.
Step 7: Determining global weights corresponding to all factors.
Step 8: Arranging evaluation scales relating to estimation of factors.
Step 9: Specifying applicants' adequacy ratings by utilizing global factor weights and evaluation scales.

3.1. Determination of Personnel Selection Factors and Building the Personel Selection Model

This survey, in which the factors within the personnel selection model are determined in a general level, is not aimed at a specific sector or workplace. Yet it differs in personnel selection criteria classification viewpoint. Examining other surveys in literature, it was observed that personnel selection model criteria were categorized in two main groups as qualitative and quantitative criteria. Personnel selection model in this study, however, hosts a third group of factors which could be denoted as 0-1 (on-off, yes-no). The network model developed in order to find out weights of the factors that are to be used in personnel selection process is shown in Figure 3.

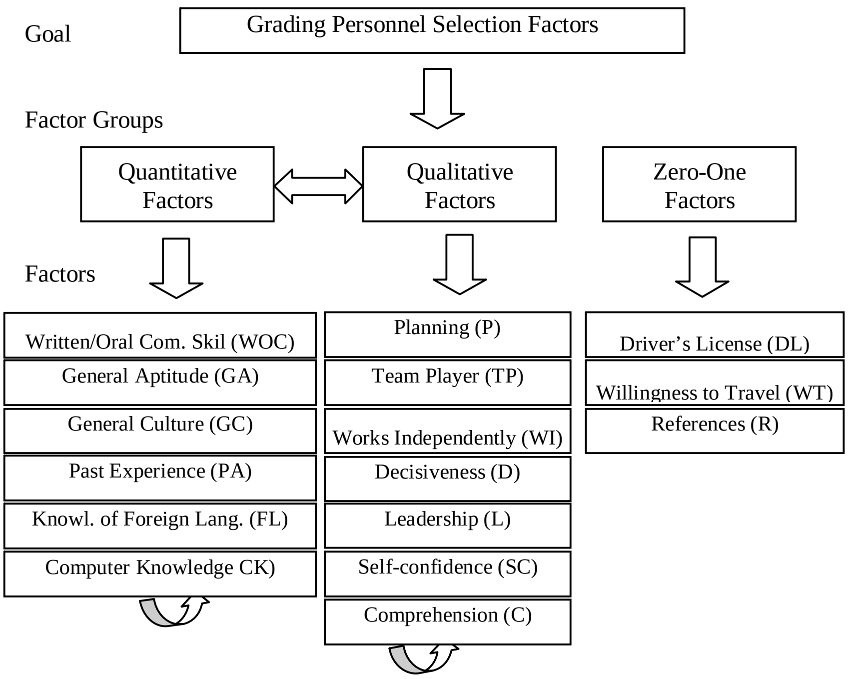

Figure 3. General ANP Model for Weighting Personnel Selection Factors

As it can be seen in Figure 3, the model developed consists of three phases. In the first phase there is the goal, that is weighting the factors in personnel selection process. Second phase consists of factor groups called qualitative, quantitative and 0-1 factors; while in the third phase, within the model there are 6 quantitative, 7 qualitative, and 3 zero-one, i.e. a total of 16 factors. There are, in the model, dependencies between qualitative and quantitative factor groups, and between sub-factors belonging to these factor groups. Such interdependencies between factors are indicated with arrows on the figure. Zero-one factor group is independent from other factor groups; likewise, the factors of this group are independent from each other.

3.2. Determining Weights of the Factors in Personnel Selection Model

After building the ANP model that aims at the solution of personnel selection problem; taking the connections between quantitative and qualitative factors as a starting point, pairwise comparison decision matrices will be created in order to determine weights of factors in the groups. The network structure demonstrating the connections between written/oral communication factor and other factors is shown in Figure 4. Pairwise comparison matrices based on these connections, along with priority vectors are given in Table 2. The method presented in Step 2 of Chapter 2 is used while obtaining priority vectors by utilizing pairwise comparison decision matrices. Similarly, other factors are also evaluated with 19 pairwise comparison decision matrices. Initial supermatrix is formed by making use of priority vectors obtained from decision matrices (Table 3). In the next stage, quantitative and qualitative factor groups are assumed to have equal priorities, and the initial supermatrix shown in Table 3 is weighted basing on this assumption. Weighted supermatrix is analyzed with MATLAB 6.5 software. Limit supermatrix is formed via raising the weighted supermatrix to the power of an arbitrarily large number. Weighted supermatrix is displayed in Table 4 and limit supermatrix is displayed in Table 5. Limit supermatrix in Table 5 exhibits the weights of factors belonging to quantitative and qualitative factor groups.

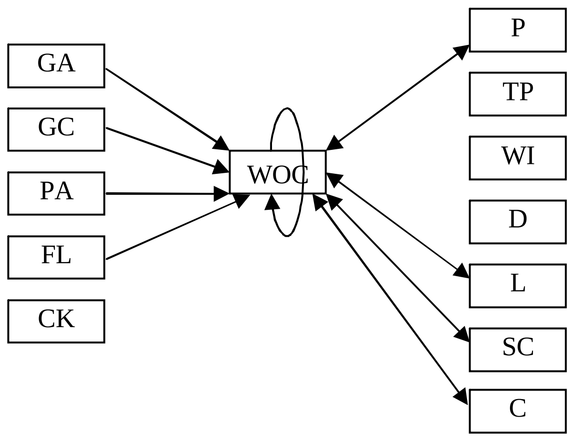

Figure 4. Network Structure Regarding WOC Factor

Table 2. Pairwise Comparison Matrices Based on Written and Oral Communication Factor

	WOC	GA	GC	PA	FL	Weights
WOC	1.00	3.00	2.00	2.00	2.00	0.350
GA	0.33	1.00	2.00	1.00	2.00	0.196
GC	0.50	0.50	1.00	0.50	1.00	0.122
PA	0.50	1.00	2.00	1.00	2.00	0.208
FL	0.50	0.50	1.00	0.50	1.00	0.122
	P	WI	D	SC	C	Weights
P	1.00	2.00	3.00	2.00	5.00	0.346
WI	0.50	1.00	2.00	2.00	3.00	0.212
D	0.33	0.50	1.00	4.00	4.00	0.206
SC	0.50	0.50	2.00	1.00	4.00	0.179
C	0.20	0.33	0.25	0.25	1.00	0.054

Table 3. Initial Supermatrix

	WOC	GA	GC	PA	FL	CK	P	TP	WI	D	L	SC	C
WOC	0.350	0.000	0.000	0.000	0.000	0.000	0.250	0.000	0.000	0.000	0.216	0.127	0.142
GA	0.196	0.476	0.086	0.000	0.000	0.000	0.250	0.000	0.000	0.286	0.199	0.280	0.339
GC	0.122	0.081	0.503	0.000	0.000	0.000	0.250	0.000	0.000	0.143	0.185	0.280	0.158
PA	0.208	0.288	0.205	1.000	0.000	0.000	0.250	1.000	0.443	0.571	0.339	0.312	0.260
FL	0.122	0.000	0.000	0.000	1.000	0.250	0.000	0.000	0.387	0.000	0.061	0.000	0.071
CK	0.000	0.154	0.205	0.000	0.000	0.750	0.000	0.000	0.169	0.000	0.000	0.000	0.030
P	0.345	0.000	0.000	0.000	0.000	0.000	0.321	0.000	0.000	0.207	0.132	0.108	0.232
TP	0.000	0.000	0.000	0.387	0.000	0.000	0.064	0.340	0.000	0.000	0.125	0.000	0.000
WI	0.212	0.000	0.000	0.140	0.000	0.000	0.119	0.000	0.455	0.180	0.000	0.302	0.000
D	0.206	0.000	0.000	0.275	0.000	0.000	0.099	0.000	0.263	0.346	0.053	0.083	0.167
L	0.000	0.000	0.000	0.000	0.000	0.000	0.198	0.281	0.000	0.000	0.415	0.000	0.000
SC	0.179	0.000	0.000	0.198	0.000	0.000	0.162	0.239	0.141	0.213	0.196	0.451	0.299
C	0.056	1.000	1.000	0.000	1.000	1.000	0.037	0.140	0.141	0.054	0.079	0.057	0.301

Table 4. Weighted Supermatrix

	WOC	GA	GC	PA	FL	CK	P	TP	WI	D	L	SC	C
WOC	0.175	0.000	0.000	0.000	0.000	0.000	0.125	0.000	0.000	0.000	0.108	0.063	0.071
GA	0.098	0.238	0.043	0.000	0.000	0.000	0.125	0.000	0.000	0.143	0.099	0.140	0.169
GC	0.061	0.040	0.251	0.000	0.000	0.000	0.125	0.000	0.000	0.071	0.092	0.140	0.079
PA	0.104	0.144	0.102	0.500	0.000	0.000	0.125	0.500	0.221	0.285	0.169	0.156	0.130
FL	0.061	0.000	0.000	0.000	0.500	0.125	0.000	0.000	0.193	0.000	0.030	0.000	0.035
CK	0.000	0.077	0.102	0.000	0.000	0.375	0.000	0.000	0.084	0.000	0.000	0.000	0.015
P	0.172	0.000	0.000	0.000	0.000	0.000	0.160	0.000	0.000	0.103	0.066	0.054	0.116
TP	0.000	0.000	0.000	0.193	0.000	0.000	0.032	0.170	0.000	0.000	0.062	0.000	0.000
WI	0.106	0.000	0.000	0.070	0.000	0.000	0.059	0.000	0.227	0.090	0.000	0.151	0.000
D	0.103	0.000	0.000	0.137	0.000	0.000	0.049	0.000	0.131	0.173	0.026	0.041	0.083
L	0.000	0.000	0.000	0.000	0.000	0.000	0.099	0.140	0.000	0.000	0.207	0.000	0.000
SC	0.089	0.000	0.000	0.099	0.000	0.000	0.081	0.119	0.070	0.106	0.098	0.225	0.149
C	0.028	0.500	0.500	0.000	0.500	0.500	0.018	0.070	0.070	0.027	0.039	0.028	0.150

After determining the weights of quantitative and qualitative factors, pairwise comparison matrix shown in Table 6 is formed with the intention of estimating the weights of factors belonging to zero-one factor group. Priority vector obtained by evaluating this matrix is assigned to be the weights of factors belonging to this group.

Table 5. Limit Supermatrix

	WOC	GA	GC	PA	FL	CK	P	TP	WI	D	L	SC	C
WOC	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
GA	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080
GC	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058
PA	0.254	0.254	0.254	0.254	0.254	0.254	0.254	0.254	0.254	0.254	0.254	0.254	0.254
FL	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047
CK	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032
P	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044
TP	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064
WI	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059
D	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077
L	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
SC	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095
C	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143

Table 6. Pairwise Comparison Matrix and Priority Vector for Zero-One Factors

Factors	DL	WT	R	Weights
Driver's Licence	1	0.33	2	0,239
Willingness to Travel	3	1	4	0,623
References	0.50	0.25	1	0,138

After the values of weights of all the factors in the model shown in Figure 3 are estimated, these factors are gathered on a common ground. In this sense, qualitative and quantitative factor groups, whose weights are determined through the supermatrix, are compared to zero-one factor group, whose weights are determined by means of the pairwise comparison decision matrix. The pairwise comparison decision matrix and priority vector formed for this purpose are given in Table 7.

Table 7. Pairwise Comparison Matrix and Priority Vector for Factor Groups

Factor Groups	QQF	ZOF	Weights
Quantitative-Qualitative Factors (QQF)	1	8	0,889
Zero-One Factors (ZOF)	0.125	1	0,111

Priority vector values shown in Table 7 are considered as weights that correspond to factor groups. Weight values found through the supermatrix are multiplied by weight values found via pairwise comparison matrix, thereby the values of global weights corresponding to the factors are calculated (Table 8).

Table 8. Global Weights According to Factors

Factor Groups	Weights	Factors	Weights	Global Weights
Quantitative and Qualitative Factors	0.889	WOC	0.030	0.026
		GA	0.080	0.072
		GC	0.058	0.051
		PA	0.254	0.225
		FL	0.047	0.043
		CK	0.032	0.028
		P	0.044	0.039
		TP	0.064	0.056
		WI	0.059	0.053
		D	0.077	0.068
		L	0.017	0.016
		SC	0.095	0.084
		C	0.143	0.128
Zero-One Factors	0.111	DL	0,239	0.027
		WT	0,623	0.069
		R	0,137	0.015
The Sum of Weights of Factors				1.000

3.3. Generating Measurement Scales to Evaluate the Factors Obtained in Personnel Selection Model

After calculating the global weights corresponding to factors, measurement scales are generated in order to evaluate these factors. Outcome of the studies performed, which are measurement scale values that correspond to quantitative factors, to qualitative factors, and to zero-one factors, are given in Table 9, 10, and 11 respectively.

Table 9.Measurement Scales for Quantitative Factors

Factors WOC, GA, GC, FL, CK		Past Experience (PA) Factor	
Interval (Grade)	Scale Value	Interval (Year)	Scale Value
90< X ≤100	1.00	9< PA	1.00
80< X ≤90	0.90	8< PA ≤ 9	0.90
70< X ≤ 80	0.80	7< PA ≤8	0.80
60< X ≤70	0.70	6< PA ≤7	0.70
50< X ≤60	0.60	5< PA ≤6	0.60
40< X ≤50	0.50	4< PA ≤5	0.50
30< X ≤40	0.40	3< PA ≤4	0.40
20< X ≤30	0.30	2< PA ≤3	0.30
10< X ≤20	0.20	1< PA ≤2	0.20
0< X ≤10	0.10	0< PA ≤1	0.10

In the first column of measurement scales of Table 9, values regarding all quantitative factors are given except past experience. Applicants' grades after brief examinations, which are carried out to evaluate these factors, are indicated with 'X's. Past experience factor presented in the second column is evaluated according to applicants' experience with respect to years.

Table 10. Measurement Scale for Qualitative Factors

Factors P, TP, WI, D, L, SC, C	
Linguistic Variable	Scale Value
Excellent	1.00
Good	0.80
Average	0.60
Fair	0.40
Poor	0.20

Qualitative factors shown in Table 10 are evaluated during the interviews with applicants via linguistic variables, which are determined by the interviewer. At the end of the interviews, according to relevant factors, applicants are graded with five linguistic variables, i.e. Excellent (E), Good (G), Average (A), Fair (F), Poor (P). Depending on these linguistic variables, grades corresponding to relevant factors are determined.

Table 11. Measurement Scale for Zero-One Factors

Factors DL, WT, R	
Answer	Scale Value
Positive	1.00
Negative	0.00

While evaluating the factors belonging to zero-one factor group, applicants' answers are taken into consideration directly. In the case of a positive answer, entire grade relating to that particular factor is added up to applicant's grade; however, in the case of a negative answer, applicant is not given a grade for that factor.

3.4. Numeric Example

In this section of the paper, an example application of the model is introduced. So, after the weights of personnel selection factors and measurement scales corresponding to these factors are determined, applicants are evaluated. At this stage, evaluation is executed depending on exam and interview results, and measurement scales. A numeric example for demonstrating the application of the model suggested in applicant evaluation is shown in Table 12.

In the example shown in Table 12, applicants are evaluated according to exam and interview results and factors. In the following phase, values of scales corresponding to these results are determined from the tables formed (Tables 9, 10, and 11). Factor points are calculated by multiplying global weights by scale values, and applicant's total grade is estimated by summing up the factor points. In this case, the applicant's competence score is 68.2%. Adequacy rating of a candidate applying for any job in the company can be found out in this fashion. Similarly, adequacy ratings of other applicants can be calculated and thus, competence of all the applicants can be determined. This way, the company gets the opportunity to perform personnel selection objectively.

Table 12. Numeric Example

Factors	Global Weights	Result of the Exam/Interview	Scale Values	Factor Points
WOC	0.026	72 points	0.80	0.020
GA	0.072	85 points	0.90	0.064
GC	0.051	70 points	0.70	0.035
PA	0.225	5 years	0.50	0.112
FL	0.043	65 points	0.70	0.030
CK	0.028	83 points	0.90	0.025
P	0.039	Good	0.80	0.031
TP	0.056	Average	0.60	0.033
WI	0.053	Good	0.80	0.042
D	0.068	Good	0.80	0.054
L	0.016	Average	0.60	0.009
SC	0.084	Good	0.80	0.067
C	0.128	Average	0.60	0.076
DL	0.027	Negative	0.00	0.000
WT	0.069	Positive	1.00	0.069
R	0.015	Positive	1.00	0.015
			TOTAL GRADE	0.682

4. CONCLUSION

In this paper, a method including interdependencies between personnel selection criteria is developed and presented. The model consists of an algorithm having nine steps. Personnel selection model comprises three stages and 16 factors in total. Number of stages and factors in the model may differ according to workplace characteristics. Therefore, it is possible to increase the number of stages and factors in personnel selection model up to the limit permitted by analytic network process model. Global weights of personnel selection factors are estimated via analytical network process. Moreover, in this paper, measurement and evaluation scales regarding the factors in personnel selection model are determined. Competence ratings of applicants are calculated by means of factor weights and measurement scales. Also in this paper, application of a candidate is demonstrated with an example.

In this study, objectivity of personnel selection method is emphasized. Nevertheless, clarifying whether a factor befits to be a criterion of not, is as important and as essential as the method itself. Because, while the method developed gives the opportunity to proceed objectively and to make the right decisions, various factors in the model represent the position applied. In a personnel selection procedure based on factors that does not define the job, wrong choices will be unavoidable, however solid the method is. That's why; factors have to be properly chosen exclusively for every sector, workplace, and position. In prospective studies, this problem can be surveyed. A study following this one should handle the development of a software algorithm that makes possible any manual alteration in the model, according to the job or the workplace in question.

The proposed model might be incapable if the pairwise comparison matrix for the factors cannot be formed with crisp values. Some factors could have an uncertain structure which cannot be measured precisely. In such cases, fuzzy numbers can be used to obtain the pairwise comparison matrix.

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