SECTION 3. General issues in management

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A two-phase multi criteria dynamic programing approach for personnel selection process

Abstract

This paper proposes a two-phase multiple criteria stochastic dynamic programing approach for personnel selection process. In the first phase, analytic hierarchy process (AHP) is employed to treat the multi-criteria nature of the personnel selection process and the process is structured in a hierarchical manner. The relative importance i.e. weights of the criteria obtained through eigenvalue calculations of AHP. In the second phase of the approach the process is divided into stages, a stochastic dynamic programming (DP) model is formulated and the calculated AHP weights of each stage-decision alternative-state are integrated to the DP model in order to obtain the optimal decision in each stage, the steps in the personnel selection process. The aim of this study is to determine the optimal decision alternative, which method to apply in each step of the personnel selection process. To show the applicability and usefulness of the proposed approach it is applied to a real life problem, a home textile manufacturer's personnel selection process.

Keywords: personnel selection process, analytic hierarchy process, dynamic programming, stochastic dynamic programming, multi criteria decision-making.
JEL Classification: C61, C44, M51.

Introduction

Human resources is a key part in an organization's success and hence effective human resource management is one of the primary success factors for an organization to gain and enhance competitive advantage in a rapidly changing knowledge-based business environment. Because of its key role on an organization's success and sustainability, selection of qualified and the appropriate human resource/personnel for an organization is an important part of human resource management decisions.

Personnel selection is the process of choosing individuals who match the qualifications required to perform a defined job in the best way. It determines the input quality of personnel and plays an important role in human resource management. Increasing competition in global markets urges organizations to put more emphasis on personnel selection process. Important issues such as changes in organizations, work, society, regulations and marketing have an influence on personnel selection and recruiting. Organizations differ with respect to the procedures and budgets for recruiting, selecting and orienting people (Afshari et. al., 2010). Although personnel selection differs among organizations, since it is an important and complicated process, using analytical methods would result in more effective and rational personnel selection decisions rather than intuitive ones.

The personnel selection problem generally concerns with important and complex issues such as: (1) How to properly set the importance weights of criteria to reflect the situations in which not all personnel attributes/characteristics are equally important? (2) How to use linguistic and/or numerical scales to evaluate the applicants under multiple criteria? (3) How to aggregate the evaluation results and then rank the applicants? The inherent importance and complexity of the personnel selection problem require effective analytical methods to provide an operational/tactical decision framework (Lin, 2010).

Many studies have been carried out personnel selection decisions. Kwak et. al. (1997) developed a human resource planning model based on Analytic Hierarchy Process (AHP) for selecting hospital laboratory personnel and Seol and Sarkis (2005) used AHP for internal auditor selection and Gibney and Shang (2007) used it in dean selection process. Shih et. al. (2005) proposed a two-phase, with eight steps in total, group decision support system using AHP and TOPSIS for selecting human resources. Jereb et. al. (2005) described an approach integrating multi-attribute decision-making methods with an expert system called DEXi for selecting a top manager. Chen and Cheng (2005) proposed a fuzzy group decision support system for selecting IS personnel based on the use of metric distance method to rank fuzzy numbers. Chang (2007) used analytic network process (ANP) to select the most suitable hosts of TV shopping channels in Taiwan. Güngör et. al. (2009) suggested a fuzzy AHP method to select the best adequate personnel according to qualitative and quantitative criteria and compared these results with those produced by Yager's weighted method. Afshari et. al. (2010) employed ELECTRE method to select the best personnel among five candidates and also AHP to rank the candidates those are in the same grade according to ELECTRE results. Kelemenis and Askounis (2010) introduced a new fuzzy TOPSIS based approach for selection of human resources incorporating the veto set by the decision maker to the traditional approach. Dağdeviren (2010) proposed a hybrid model using ANP for calculating the weight of the interdependent selection criteria and TOPSIS for ranking the candidates to select the most suitable personnel in a manufacturing firm. Lin (2010) introduced an ANP and fuzzy data envelopment analysis (DEA) integrated three-phase method for personnel selection process, using ANP to obtain relative weights of criteria and output oriented fuzzy DEA model for evaluating and ranking applicants. Hsiao et. al. (2011) used AHP to determine the weights of selection criteria of information systems employees. Fengru and Lili (2011) proposed a fuzzy TOPSIS method for selecting personnel based on team characteristics. Shahhosseini and Sebt (2011) used fuzzy AHP approach and ANFIS and Chou et. al. (2012) integrated fuzzy AHP and fuzzy DEMATEL approaches for personnel selection.

Unlike other studies, the aim of this paper is selecting the methods in each step of the personnel selection process to speed up the procedure, rather than deciding the best individual for a job among candidates. To that end this paper develops a dynamic multi-criteria decision framework for personnel selection process. For this purpose in this study we try to develop a Dynamic Programing (DP) model with the steps of the personnel selection process as stages of the system and integrate the weights obtained through a well-known and extensively used multi-criteria decision making method analytic hierarchy process (AHP) to the DP model.

AHP was initially developed by T.L. Saaty in the 1970s to deal with multiple criteria in decision making processes and after his first book in 1980 the method was extended by several scholars and because of its ease of use and simplicity applied in a wide range of fields.

AHP structures the complex decision making problems in a hierarchic manner, perform measurement on a ratio scale for all components of the hierarchic structure and synthesis the results (Forman and Gass, 2001). Numerous applications have been made in areas such as credit evaluation and various investment decisions, customers' product selection decisions, education, facility location decisions, hardware and software selection, healthcare, performance evaluation, personnel selection (as mentioned above), portfolio selection, new product development, product mix decisions, production/inventory planning and control, project and contractor selection decisions in project management, public policy decisions, reengineering and QFD, resource allocation and assignment, supplier/vendor selection, technology selection etc.

Dynamic programming, the solution approach of this study, is a mathematical optimization approach, introduced by Bellman (1957), which deals with multistage decision problems that involve making a sequence of decisions. Over the years DP has been employed to solve many real life decision problems such as resource allocation, production/order scheduling, inventory replenishment, marketing, capital budgeting, machine/equipment maintenance and replacement problems, manpower planning and so on. DP model was used for manpower planning in previous studies, for instance Bishop and Rockwell (1958) and Rao (1990) used DP to determine the optimal recruitment schedules minimizing the manpower system costs. Mehlmann (1980) employed DP approach to deal with how changes or transitions take place across different classes (grades) of the system. Zanakis and Maret (1981), Kornbluth (1981), Kalu (1994, 1999), Georgio (1999), Georgio and Tsantas (2002) have used a Markovian goal programing model for manpower planning problems. Cai et. al. (2010) studied DP to determine the optimal number of employees in different categories. Ogumeyo (2010) has discussed a dynamic programing approach to decide the optimal workforce size and find the minimum recruitment cost. Nirmala and Jeeva (2010) formulated a DP model to determine the minimum-cost/optimal recruitment and promotion policies. Li et. al. (2010), presented a forward DP recursion to find the schedule of recruitment/dismission of employees minimizing the total manpower-related cost.

The novelty of this study comes from the fact that DP model had not been used before in personnel selection process. Hence AHP weights will also be used in a DP model for the first time for personnel selection decisions. Also we did not focus on selecting the best candidate, our aim is to determine the selection method in the proper stages of the defined personnel selection process. The rest of this paper is organized as follows: In the next section we present the theoretical background for the integrated model in brief, a review of relevant literature for the integration of AHP and DP approaches and describe the proposed model. Section 2 provides an empirical application using the proposed DP-AHP model. The final section concludes the paper with a summary of our findings.

1. Formulation of the DP model using AHP weights for personnel selection process

As mentioned before we proposed a DP model using the weights calculated by using AHP. Therefore, in this section we presented a brief theoretical background for both AHP and DP approaches and afterwards treated the proposed DP-AHP mathematical model with the support of relevant literature.

1.1. Analytic hierarchy process. AHP has five main steps as: defining the problem, decomposition of the problem in order to obtain a hierarchic structure (goal-criteria-sub criteria), construct pairwise comparison matrices for each element in the hierarchy comparing with respect to the upper level element, measuring the consistency of those matrices and calculating the weights of all elements of the hierarchy, and finally synthesizing the results in order to obtain overall score or global weight of the elements named as alternatives appearing in the bottom of the hierarchy.

The AHP is based on four axioms: (1) reciprocal judgments, (2) homogeneous elements, (3) hierarchic or feedback dependent structure, and (4) rank order expectations. The synthesis of the AHP combines multidimensional scales of measurement into a single "unidimensional" scale of priorities. Decisions are determined by a single number for the best outcome or by a vector of priorities that gives a proportionate ordering of the different possible outcomes to which one can then allocate resources in an optimal way subject to both tangible and intangible constraints (Saaty, 2005). Those axioms are used to describe two basic tasks in the AHP: formulating and solving the problem as a hierarchy and eliciting judgments in the form of pairwise comparisons (Harker, 1989). Pairwise comparisons are made by using Saaty's 1-9 scale shown in Table 1 (Saaty, 1986). All judgments (denoted by a_{ij}) are represented in a square pairwise comparison matrix (A, composed of a_{ij}). Each judgment in the matrix shows the intensity of the importance, such that the importance of the element in the row against the importance of the element in the column of the matrix.

Table 1. Scale of relative importance

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

To arrive consistent judgments, acceptable inconsistency level has to be determined. Consistency ratio (CR) is calculated by dividing the consistency index (CI) – the computed principal eigenvalue (λ_{max}, calculated through $Aw=\lambda_{max}w$) of the pairwise comparison matrix normalized by the matrix size to average random index (RI) that is obtained from Saaty's RI table depending on the matrix size. Saaty suggests that a CR of 0.1 or less is considered as acceptable.

1.2. DP approach. DP is a very useful technique for making a sequence of interrelated decisions. It requires formulating an appropriate recursive relationship for each individual problem. However, it provides a great computational savings over using exhaustive enumeration to find the best combination of decisions, especially for large problems (Hillier and Lieberman, 2001). DP solves optimization problems by determining, for each decision, subproblems that can be solved in like fashion, such that an optimal solution of the original problem can be found from optimal solutions of subproblems (Lew and Mauch, 2007).

The theory of dynamic programing treats problems involving multi-stage processes by means of a transformation of the problem from the space of decisions to the space of functions. This is accomplished by deriving a functional equation whose solution is equivalent to the solution of the original problem (Bellman, 1954). In each process or system, the functional equation governing the process is to be obtained by an application of the following intuitive, Bellman's Principle of Optimality: "An optimal policy has the property that whatever the initial state and initial decision are, the remaining decisions must constitute an optimal policy with regard to the state resulting from the first decision" (Bellman, 2003).

The problem can be divided into stages, with a policy decision required at each stage. Each stage has a number of states associated with the beginning of that stage. The states are the various possible conditions in which the system might be at that stage of the problem. The effect of the policy decision at each stage is to transform the current state to a state associated with the beginning of the next stage (possibly according to a probability distribution). The solution procedure is designed to find an optimal policy for the overall problem, i.e., a prescription of the optimal policy decision at each stage for each of the possible states. The solution procedure begins by finding the optimal policy for the last stage. The optimal policy for the last stage prescribes the optimal policy decision for each of the possible states at that stage. A recursive relationship that identifies the optimal policy for stage *n*, given the optimal policy for stage *n*-1, is available (Hillier and Lieberman, 2001). The optimal solution of the problem is obtained by starting from the last stage and moving backward stage by stage.

In deterministic DP problems, in each stage, the state of the process or system at the next stage can be determined by the current state and decision made at that stage. However in stochastic DP problems there is a probability for what the next state of the system will be in the next stage.

For stochastic DP problems, the recursive functional equation can be written in the following form (Howard, 1960):

$$f_i(n) = \max_k \sum_{j=1}^{N} p_{ij}^k \left[r_{ij}^k + f_j(n-1) \right], \quad (1)$$

where $f_i(n)$ denotes for the total expected return when the state of the system is i and there are n remaining stages to the end of the process. Simply it is the expected total value in the next n transitions if the process or system is now in state i. The optimal policy is the one that maximizes the total expected return for each state i and each stage n. k denotes for the decision alternatives, p_{ij}^k shows the transition probability of the system to be in state j at the next stage that is in state i and the alternative k is chosen at the current stage. r_{ij}^k is the reward (profit or cost) related to this transition.

1.3. Proposed DP-AHP mathematical model. A detailed literature search showed that several approaches have been integrated with AHP but a few studies exist incorporating AHP weights in to the DP models and we could not reach any studies integrating DP with AHP for personnel selection processes. Benjelloun (2003) proposed a backward DP model integrating the AHP and introduced an approach treating the transition probabilities as estimates in his Ph.D. dissertation. Proposed model was applied to the design process of an automobile, taking each step of the design process as the states of the dynamic model. Stirn (2006) integrated fuzzy AHP with DP to determine optimal forest management decisions. In the first stage of the two-stage model, economic-ecological-social-educational objectives of forest management decisions and their related attributes were presented in a hierarchical structure and fuzzy AHP weights were computed. And in the second stage a network diagram was constructed for the problem and solved using backward DP recursion. Yang et. al. (2010) proposed a dynamic critical path computation algorithm integrating DP and AHP approaches. In the first step of the algorithm among several paths in a network, the least infrastructure used paths, the least material consumed paths and the paths with minimum time are determined according to three distinct DP recursive functional equations. After selecting those candidate paths, in the second step of the algorithm they used AHP to make comparisons among those paths according to three criteria (infrastructure, material and time) and calculated the weights of the criteria. The global weights of the selected candidate paths were also computed and three paths were sorted according to their global weights (or final score). Mafakheri et. al. (2011) proposed a two-stage multiple criteria DP approach, using AHP in the first stage for supplier ranking and in the second stage incorporating those weights for order allocation DP model. A distance-to-ideal framework was employed to integrate the two objectives, minimization of total cost of purchase and maximization of total value of purchase.

In this paper we proposed a two-phase DP-AHP model for personnel selection process. In the first phase, weights of criteria and sub-criteria are calculated using pairwise comparison matrices and AHP. In the second phase those weights are integrated to the stochastic DP recursive equation (1) and the AHP weighted DP model is constructed. By using backward recursion the optimal solution will be obtained. All candidates entering the process will be subject to the every step of the selection process applied and will not be rejected until the process ends.

In the proposed model, personnel selection process is divided into steps. Every step in personnel selection process corresponds to a stage in our DP model. Those stages are also the multiple criteria of the hierarchical structure of the AHP to select the adequate personnel for the job. We integrate the weights computed by AHP to the DP backward computations of the related stage. At each stage of the system the decision maker has to decide an alternative and different from other DP-AHP integrated studies (Benjelloun, 2003; Stirn, 2006 and Yang et. al., 2010) those alternatives are the sub-criteria of the criteria (the stages of DP model) on the upper level and their weights are also included in the model. Our aim is to select the optimal alternative at each stage, every step in the personnel selection process, by the way to fasten this process. There exist evaluation grades for every sub-criteria in the hierarchy. The weights of those grades, sub criteria-third level, are also calculated through AHP method. Then the DP-AHP model can be formulated as follows:

$$f_i(n) = \max_k w_j^k(n)\left[\sum_{j=1}^{N} p_{ij}^k r_{ij}^k a_j(n) + p_{ij}^k f_j(n-1)\right], \qquad (2)$$

$w_j^k(n)$ is the weight of decision alternative k (sub criteria – second level of AHP hierarchy) available for each state of DP model when there are n stages to complete the process. $a_j(n)$ denotes for the weight of stages (main or first level criteria of AHP hierarchy) multiplied by the weight of states (the evaluation grades or sub criteria – third level of the hierarchy) at the end of each stage of the process. Recall that in (1) r_{ij}^k represents the reward related to the transition from state i to j when the decision is alternative k. In our model it stands for the scores of evaluation grades. For instance "mostly suitable" at the end of a step in personnel selection process means the candidate has a 70-100 score, since we take the midpoints his/her score is 85. Those scores do not vary depending on the alternatives because we assumed the same scale for all alternatives, therefore the superscript k can be omitted from the notation r_{ij}^k. $f_i(n)$ is the total expected score of a job candidate when the state of the process is i and there are n stages to complete the personnel selection process.

2. A sample case study

The purpose of the sample case study is to illustrate the use and applicability of the proposed DP-AHP model for personnel selection process. To this end, we present the case of a home textile manufacturer in Turkey. We applied the DP-AHP model to the manufacturer's personnel selection process for a marketing department position.

The personnel selection process of the company has five main steps shown in Figure 1: (1) determining the suitability to the position, according to education-experience-foreign language-technical skills; (2) examination; (3) individual interview; (4) group interview and (5) reference search.

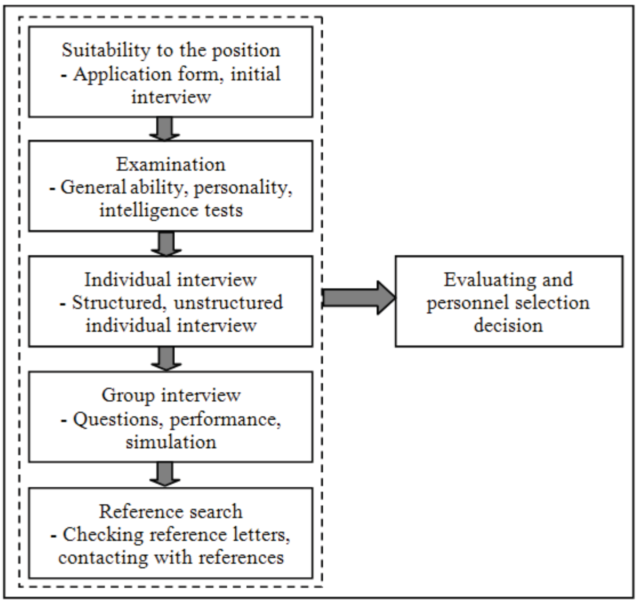

Fig. 1. Personnel selection process for the manufacturer

In each step of the process several techniques are used. For instance to determine the candidates' suitability to the position, company uses an application form (AF) and initial interview (II). In the second step, general ability test (GAT), personality test (PT) and intelligence test (IT) are conducted. The third step of the selection process involves structured (SII) and unstructured (UII) individual interviews, group interview step includes asking questions (Q) and performance simulation (PS) through case studies and final step requires checking reference letters (CRL) and contacting with references (CWR). The evaluation grades as a result of using those methods are scaled on a three-level basis, i.e., a candidate's suitability to the position according to application form or initial interview is measured by using a three-level scale labeled as mostly, moderate and slightly suitable.

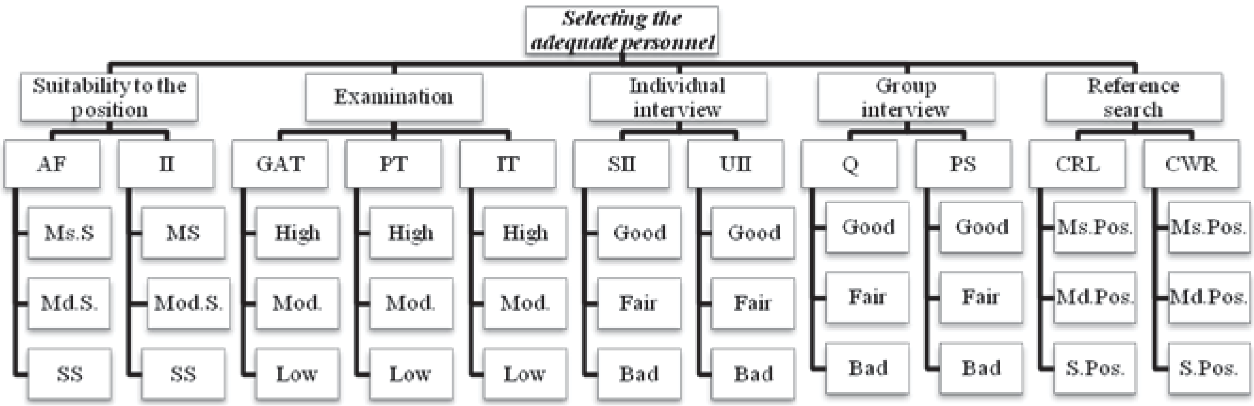

Fig. 2. AHP hierarchy for personnel selection problem

In the first phase of our approach we have presented the hierarchical structure for the company's personnel selection process and calculated the required weights for our DP model. The AHP hierarchy is given in Figure 2. The first level criteria in the hierarchy present the five main steps of company's selection process. The second level criteria (or sub-criteria) shows the methods used in each step of selection process. And the evaluation grades for each of those methods appear in the third level criteria (or sub-criteria of second level).

To obtain the weights of determined criteria and sub-criteria, we construct pairwise comparison matrices by the opinion of actors involved in the personnel selection process of the company. An example pairwise comparison matrix, for the criteria comparisons (with calculated *CR* value) is shown in Table 2. Those computed weights show that group interview and individual interview is the key part of personnel selection process for the company with the highest weights compared to other steps.

Table 2. Example pair-wise comparison matrix and relative importance (weights) of main criteria for personnel selection process

CR = 0.0820	Suit. to the pos.	Exam.	Ind. int.	Group int.	Ref. search	Weights
Suit. to the pos.	1	3	1/3	1/2	3	0.1728
Examination	1/3	1	1/5	1/3	3	0.0965
Ind. int.	3	5	1	1/2	3	0.3120
Group int.	2	3	2	1	5	0.3579
Ref. search	1/3	1/3	1/3	1/5	1	0.0608

Similar comparisons have been made for all of the sub-criteria appear in different levels in the hierarchy and the computed weights, also the *CR* values are presented in Table 3.

In the second phase of proposed DP-AHP approach, we have structured the personnel selection process as a DP model, each step of the process represented as a criterion in the AHP hierarchy corresponds to a stage of DP structure. At the end of each step a candidate beginning to the process will be in one of the states (the third level sub-criteria in the hierarchy) of related stage with a known transition probability according to the selected decision alternative which was represented as the second level sub-criteria in our hierarchic structure.

Table 3. Criteria and sub-criteria weights of personnel selection problem

Criteria (1st *level*)	Criteria weight	Sub-criteria (2nd *level*)	Sub-criteria weights	*CR*	Sub-criteria (3rd *level*)	Sub-criteria weights	*CR*
Suitability to the position	0.1728	AF	0.2500	0.00	Ms. Suit.	0.6370	0.03
					Md. Suit.	0.2583	
					Sl. Suit.	0.1047	

Table 3 (cont.). Criteria and sub-criteria weights of personnel selection problem

Criteria (1st level)	Criteria weight	Sub-criteria (2nd level)	Sub-criteria weights	CR	Sub-criteria (3rd level)	Sub-criteria weights	CR
Suitability to the position	0.1728	II	0.7500	0.00	Ms. Suit.	0.7306	0.06
					Md. Suit.	0.1884	
					Sl. Suit.	0.0810	
Examination	0.0965	GAT	0.1692	0.02	High	0.7352	0.10
					Mod.	0.2067	
					Low	0.0581	
		PT	0.3874		High	0.6370	0.03
					Mod.	0.2583	
					Low	0.1047	
		IT	0.4434		High	0.6491	0.06
					Mod.	0.2790	
					Low	0.0719	
Individual interview	0.3120	SII	0.3333	0.00	Good	0.6491	0.06
					Fair	0.2790	
					Bad	0.0719	
		UII	0.6667		Good	0.6370	0.03
					Fair	0.2583	
					Bad	0.1047	
Group interview	0.3579	Q	0.2500	0.00	Good	0.6491	0.06
					Fair	0.2790	
					Bad	0.0719	
		PS	0.7500		Good	0.6483	0.00
					Fair	0.2297	
					Bad	0.1220	
Reference search	0.0608	CRL	0.8333	0.00	Ms. Pos.	0.7049	0.03
					Md. Pos.	0.2109	
					Sl. Pos.	0.0841	
		CWR	0.1667		Ms. Pos.	0.6370	0.03
					Md. Pos.	0.2583	
					Sl. Pos.	0.1047	

The dynamic structure of the problem is shown in Figure 3. For instance, a candidate participating into the process, after completing step 1 (stage of DP model) will be in one of the three states: mostly, moderate or slightly suitable for the position as a result of either application form alternative or initial interview alternative available in stage 1. The manufacturer applies both alternatives but we suggest deciding one of those alternatives would fasten the personnel selection process and provide advantage. So our focus is on the selection of decision alternative in each stage, rather than selection of the most appropriate individual for the required position at the company.

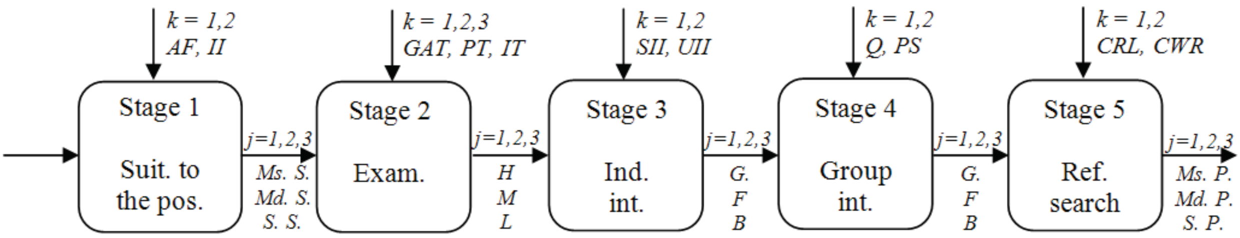

Fig. 3. DP structure for personnel selection problem

Since any candidate participating this process will not be absolutely at a known state, an individual's transition from any state i to state j at the end of each stage should be represented by the related transition probability matrices depending on the selected decision alternative. For instance transition probability matrices subject to the selected $k = 1, 2, 3$ for stage 2 shows an individual's probability to be in state j (high, moderate or low score on examination) at the end of stage 2 given the individual is in state i (mostly, moderate or slightly suitable to the position) at the end of previous stage 1 i.e. at the beginning of stage 2). All transition probability matrices are constructed using the past data and knowledge of the company's experts involving in the personnel selection process. Because those matrices can take too much space in our paper we only give an example transition probability matrix for stage 2 for decision alternative $k = 1$ as shown in Table 4. The probabilities given in that matrix reflects an individual's probability to have a high/moderate/low score on examination given that he/she is mostly/moderate/slightly suited to the job and at stage two a general ability exam has been performed.

Table 4. Example transition probability matrix for stage 2

k=1 (*GAT*)	High	Mod.	Low
Ms. Suit.	0,65	0,25	0,10
Md. Suit.	0,35	0,50	0,15
Sl. Suit.	0,20	0,45	0,35

Recursive stochastic DP equation (2) revisited and adopted for the case study in equation (3) considering all stages of personnel selection process. Since at the end of stage 5 the process terminates $f_j(0) = 0$ for every state *j*.

$$f_i(n) = \max_k w_j^k(n)\left[\sum_{j=1}^{3} p_{ij}^k r_{ij} a_j(n) + p_{ij}^k f_j(n-1)\right], \quad (3)$$

$j = 1, 2, 3$ and $k = 1, 2$ (for stage 2; $k = 1, 2, 3$).

In order to solve the above DP model recursively, we also need the rewards r_{ij}, which are the scores of evaluation grades (states in each stage) we mentioned before. At every stage of the system, being in a particular state means the candidate will have a score, defined by a grade range. Those ranges are determined as follows: being at the most favorable state (such as mostly suitable or high score on exams) equals to a range of 70-100 points, a less favorable state (moderate) means a point range of 30-70 and the least favorable state has a grade range of 0-30. For simplicity we take the midpoints of these ranges, so the scores or the rewards are 85, 50 and 15 for those states respectively.

Substituting all inputs – AHP weights, transition probabilities and rewards – in our stochastic DP formulation and solving it by backward recursion starting from the last stage, stage 5, of the personnel selection process we have obtained the results summarized in Table 5 below. Table 5 shows results of both DP models, that is incorporating AHP weights and the model without those weights.

Table 5. Optimal solutions of the DP models

Stage	Given state $i = 1,2,3$	DP solution without AHP weights			DP-AHP solution		
		Decision *k*	$f_i(n)$	Resulting state $j = 1,2,3$	Decision *k*	$f_i(n)$	Resulting state $j = 1,2,3$
1 ($n = 5$)	---	1	234.0969	2	2	2.0391	1, 2
2 ($n = 4$)	1	1	165.8370	1	1	1.7543	1
	2	1	182.9241	2	2	1.9667	2
	3	2	204.7022	2	2	1.9407	2
3 ($n = 3$)	1	1	128.0025	1	2	1.6223	1
	2	2	138.3613	1	2	2.1910	1
	3	2	172.9508	3	2	1.4934	3
4 ($n = 2$)	1	1	68.2375	1	2	1.1990	1
	2	2	81.1000	1	2	1.2254	1
	3	2	131.5000	3	2	0.9136	3
5 ($n = 1$)	1	1	44.7500	1	2	0.4916	1
	2	1	46.5000	2	2	0.4915	2
	3	2	71.0000	3	2	0.4656	3

The optimal policies shown in the table can be illustrated by the following sequence of decisions and state transitions when the DP-AHP model is used as highlighted in the right side of the table. In stage 1 ($n = 5$) the company selects the second alternative available in that stage and hence has an initial interview with the candidate to determine his/her suitability to the job position. At which state the candidate will be at the end of this stage is not certain but by selecting the second alternative, most likely transition i.e. with the highest transition probability (0.35) would be to state 1 or 2. The resulting state columns in the above table show these transitions. If we suppose this, then the candidate is mostly or moderate suitable for the job. Beginning in those states to stage 2 ($n = 4$), first or second alternatives should be selected for examination. Those alternatives correspond to general ability test and personality test respectively. If GAT is selected at this stage then the transition with the highest probability (0.65) is to state 1-high score on exam at the end of this stage and with a probability of 0.50 to state 2-moderate score on exam if the PT is selected. In stage 3 ($n = 3$), whether beginning with high or moderate score on exams, the decision alternative to be chosen is the second alternative, an unstructured individual interview and the expected resulting state is 1-good performance on UII with a transition probability of 0.80 and 0.70 respectively for the two alternatives, based upon this choice at the end of this stage. In the fourth stage (n = = 2) of the process, depending on the resulting state of previous stage, that is a good performance on unstructured individual interview, the decision maker determines the optimal decision alternative as the second alternative (performance simulation) for group interview. Depending on this alternative we expect a candidate would be in state 1, a good performance on performance simulation at the end of group interview stage with a probability of 0.90. And at the terminal stage (n = 1), beginning with a good performance on PS at the end of previous stage indicates selecting the second decision alternative (contact with references) for reference search. By this way the expected final outcome or resulting state is the first state that is a candidate being mostly positive referenced with a probability of 0.40. At the end of the personnel selection process a candidate's expected weighted score is 2.0391.

According to the left side of Table 5, results of DP model without AHP weights are close to DP-AHP solution with a few variations appeared. By using this model the optimal decision is to use application form to determine an individual's suitability to the job position. As a result we expect the candidate to be moderate suitable for the position (probability is 0.50). Beginning in this state to stage 2 optimal decision has to be GAT for examination stage and most likely transition would be to a moderate score on examination with a probability of 0.50. If a candidate has a moderate score on examination then at the next stage UII should be selected for individual interview resulting a good performance (probability is 0.70). A good performance on individual interview requires selecting the questions alternative for the next, i.e. group interview stage. This decision alternative most likely results with a good performance on group interview stage with a probability of 0.85. And finally beginning with a good performance on questions, at the last stage of the process optimal decision is to contact with references and we expect the resulting state to be a mostly positive referenced candidate. Also the results of both models are close to each other, the DP model with AHP weights allows the decision makers to integrate their preferences and assessments to the process.

Summary and conclusions

Human resources play an important role on an organization's success and sustainability in the competitive business environment. So selecting the most suitable personnel is a critical task in human resource management. The aim of this paper was to support and fasten the personnel selection process by using a dynamic multi-criteria framework that is the integrated DP-AHP approach.

The complexity and great importance of personnel selection decisions entails using analytical methods rather than the intuitive ones. Considering those aspects, this paper aimed structuring this complex process by dividing it to several stages and employ DP approach for this purpose. Then AHP was used in order to integrate the individual and may be subjective value judgments made by decision makers of this process into the model. This enabled us to structure the problem in a hierarchic frame and calculate the relative importance of all the elements in the hierarchy. Our focus was not on selecting the best individual for a position, instead of this we intended to identify the optimal decision for each step of the personnel selection process by solving the stochastic and weighted DP model so as to shorten the process if possible. We used the proposed approach for a manufacturing company's personnel selection process and determine the optimal decisions. The proposed model has practical implications as the results of this application showed.

In conclusion we can say that the main contribution of this paper is the formulation of a stochastic DP model for personnel selection process, a multiple-criteria and multi-stage decision process. Stochastic DP model covers the uncertainties in the decision making process and AHP enables us to address the multiple criteria features of the problem and incorporates the judgments of decision makers. A future step to this study can be the integration of DP approach with other multiple criteria methods and also applying the proposed model to other multi-stage problems.

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