An Effective Model for Intelligent Employee Selection in Human Resource Management

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Abstract

The Human resource is the most strategic resources for a society and thus for every type of organization. Therefore, choosing employees does play a major role in the productivity of an organization. One of the most important managerial responsibilities is to select new employees for vacant positions. The use of intelligent methods for decision-making in the different branches of human resource management is of high value especially in today's organizations. For this purpose, knowledge acquisition about the organization and its jobs is very essential. It helps the human resources managers to achieve optimal decision making in respect to the selection process and the other personnel operations. The knowledge acquisition, which is the extraction of knowledge from sources of expertise and its transfer to the knowledge base, is the bottleneck in expert systems development. In this paper, we use a nonmetric Multidimensional Scaling(MDS) technique for the acquisition of the required knowledge in the selection process with regard to the hidden mental structure of the organizational experts. The acquired knowledge is next used for the development of an expert system.

Keywords: human resource management, selection process, knowledge engineering, multidimensional scaling.

Introduction

Human Resources Management (HRM) is the utilization of human resources (HR) at work to achieve organizational and individual goals by recognizing HR as a crucial element (Milkovich & Boudreau, 1991). The

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use of intelligent and systematic methods in HRM and personnel operations of an organization certainly has a great impact on organizational evolution. Expert systems are used today by most large and medium organization as an important tool for improving productivity. Such systems work better than any human expert for decision making in a specific area. Some of the most important personnel operations of an organization, which can use expert system, are as follows:

- Decision making about selection of the best applicant for a job and the most suitable job for an applicant with respect to the organization's and applicant's characteristics.
- Decision making about suitable future jobs for employees in the job rotation system with respect to employees and organizational characteristics.
- Decision making concerning required training courses for employees with respect to their characteristics.
- Presenting a clear image of the working environment and career prospects.

To many managers selection is a headache: job descriptions have to be written, advertisements placed, a shortlist of candidates agreed upon, assessment of candidates carried out and a final decision reached. The process is time-consuming, costly and an unwanted interruption of critical business activities (Anderson & Shackleton, 1990).

Usually personnel and line management use a variety of imperfect methods to aid the task of predicting which applicant will be most suitable in meeting the requirements of the job. They draw on their expertise to recommend the most effective selection methods for each particular job or group of jobs (Torrington & Hall, 1998).

Some of the selection methods, which are usually used, are: the use of application forms, self assessment, telephone screening, testing (such as: aptitude,

intelligence, trainability, personality, interest test, ...), interviewing, group methods and work sampling. A combination of selection methods is usually used, based on the job nature, cost, time, accuracy, culture, acceptability etc. Regardless of the methods mentioned above, (Lewis, 1985) suggests that selection criteria can be seen in three aspects:

- Organizational criteria
- Functional / departmental criteria
- Individual job criteria

Finally, for completing a correct selection and appointment, we must consider adaptation of the job and departmental and organizational characteristics to the applicant characteristics.

The first step for all the methods (as mentioned above) in the selection of new employees, is to extract the basic selection criteria for job/person specification. There is a wide range of formats for job/person specifications criteria. The two most widely known are Alec Rodger's seven-point plan and John Munro Fraser's Five-fold framework (as shown in Table 1).

Table 1 Rodger's seven point plan and Fraser's five-fold grading (Torrington & Hall, 1998)

Seven point plan	Five – fold grading
Physical make-up	Impact on others
Attainments	Qualifications or acquired knowledge
General intelligence	Innate abilities
Special aptitudes	Motivation
Interests	Adjustment or emotional balance
Disposition	
Circumstances	

These criteria are job-related and usually come from job analysis along with experts' judgments. This is the most important step in the selection process and is done on the basis of expert judgment about the required persons' specifications for successful performance in a specific organizational job. In this method, the judg-

ments are usually colored with error and the hidden mental structure of the experts isn't considered. Consequently the extracted criteria aren't perfect. Hence, the results of the selection process aren't acceptable for managers. To extract basic expert criteria for successful job performance, we use multidimensional scaling model (MDS).

Multidimensional Scaling

The multidimensional scaling technique has been developed in the psychometric field for finding the hidden structure in experimental data. Multidimensional scaling (MDS) is a procedure to represent n alternatives geometrically by n points in a low-dimensional space, in which, each point represents an alternative. The distance between each two points in this space has a strong relation to the similarity (or dissimilarity) between that pair of alternatives. The meaning of the alternative depends on the application of the MDS. In this paper, an alternative is an employee or a jobholder.

MDS as statistical analysis method consists of two main metric and nonmetric classes. It depends on whether the similarities in data are qualitative (nonmetric MDS) or quantitative (metric MDS). Suppose that there are n alternatives and we are going to represent them by n points in a low-dimensional space by using MDS, we have the following basic definitions:

Proximity (p_{ij}): The term proximity is used in a generic way to denote similarity or dissimilarity values. For similarities, a high proximity indicates that the alternative pair is very similar. The symbol p_{ij} denotes the proximities between each pair of alternatives i and j. These data may come from a subjective evaluation about the pairs of alternatives, which are presented to some experts. In metric MDS, p_{ij} is measured as a ratio scale, but in nonmetric, it is measured as an ordinal scale. In other words, we have the rank-order of the

proximities. These ordinal values are represented as an n × n lower diagonal matrix, which is named proximity matrix.

Number of dimensions (t): The number of dimensions for geometric space, which is usually 2 or 3.

Configuration (X): The coordinates of the n points that represent n alternative, relative to t Cartesian coordinate axes.

Stress (S): The index of fitness or correspondence between the resultant configuration after solving MDS, and the proximity data. If the stress is less than or equal to 5 percent, the fitness will be good (Kruscal, 1964).

Using Nonmetric MDS for the Extraction of the Basic Criteria

For the use of nonmetric multidimensional scaling in the extraction of the basic selection criteria according to the mental structure of the experts, we will have the following stages (Fathian, 2002).

Determination of the Primary Selection Criteria

At this stage, with regard to well-known job/person specifications criteria (as shown in Table 1), and interviewing organizational experts, we determine the primary selection criteria for each of the considered organizational jobs.

Obtaining Proximities

In order to have the proximities of a set of alternatives, we usually achieve some judgments to give the similarity or dissimilarity of the pairs of alternatives, in an ordinal form. These ordinal values are represented as an n × n lower diagonal matrix, which is named proximity matrix as:

$$P = \begin{matrix} 1 \\ 2 \\ 3 \\ \cdot \\ \cdot \\ n \end{matrix} \begin{bmatrix} - & & & & \\ p_{21} & - & & & \\ p_{31} & p_{32} & - & & \\ \cdot & & & & \\ \cdot & & & & \\ p_{n1} & p_{n2} & \cdot & p_{n,n-1} & - \end{bmatrix}$$

Here, for obtaining the proximity matrix we should

perform the following steps:

- For the considered job, we choose the number of the existent jobholders (employees) in the organization who have work experience good enough (For example more than two years). The higher the number the more the exactness.

- For each of the pairs of jobholders, we get the performance similarity value between that pair of employees through interviewing managers and organizational experts. In other words, for obtaining the proximity matrix, we must consider all the possible pairs of jobholders and assess the performance similarity between the jobholders in each of the pairs. The performance similarity (proximity) is measured as an ordinal scale. So, we have the rank-order of the proximities and type of nonmetric MDS.

For example, if the number of jobholders for the considered job is five persons, we will have ten pairs. Therefore, the performance similarity(proximity) for each of pairs is measured as an order from one to ten.

Solving the Nonmetric MDS

At this stage, by using the proximity matrix, we solve nonmetric MDS and extract the coordinates of the n points that represent jobholders in a geometric space (e.g. configuration). In other words, this configuration represents the mental structure of the organizational experts about the performance of the chosen jobholders.

There are some algorithms for solving nonmetric MDS (Borg & Groenen,1997).Several computer programs for doing MDS exist, some of which are included in major software packages such as SAS, STATISTICA and SPSS.

The Jobholders' Evaluation Respecting the Primary Selection Criteria

At this stage, the chosen jobholders are evaluated respecting the primary selection criteria that come from the first stage. The evaluation is done on the basis of

judgments of the aware persons in an interval scale. Therefore, we will have scores for jobholders respecting the criteria.

The Use of Linear Multiple Regression for Extraction of the Basic Criteria

At this stage by using the solution of nonmetric MDS and the results of jobholders' evaluation in the previous stages, the basic selection criteria are extracted. For this purpose, we perform a linear multiple regression using the jobholders' evaluation values respecting the primary criteria as the dependent variables and the coordinates of the configuration as the independent variables. We seek some of the primary criteria, which have a good linear combination of the coordinates of the configuration. The multiple correlation coefficient (R) is one measure of how well this can be done. Such criteria are accepted by the mental structure of the experts.

In linear multiple regression, if the dependent variable denotes as Y and the independent variables denote as X_i (i = 1,..n), the estimated regression equation will be expressed as:

$$(1) \qquad Y = a + b_1 X_1 + b_2 X_2 + .. b_n X_n$$

In this equation Y represents the estimated value for Y and the multiple correlation coefficient (R) will be expressed as (Triola, 2000):

$$(2) \qquad R = \sqrt{1 - \frac{\sum (Y - Y)^2}{\sum (Y - \overline{Y})^2}}$$
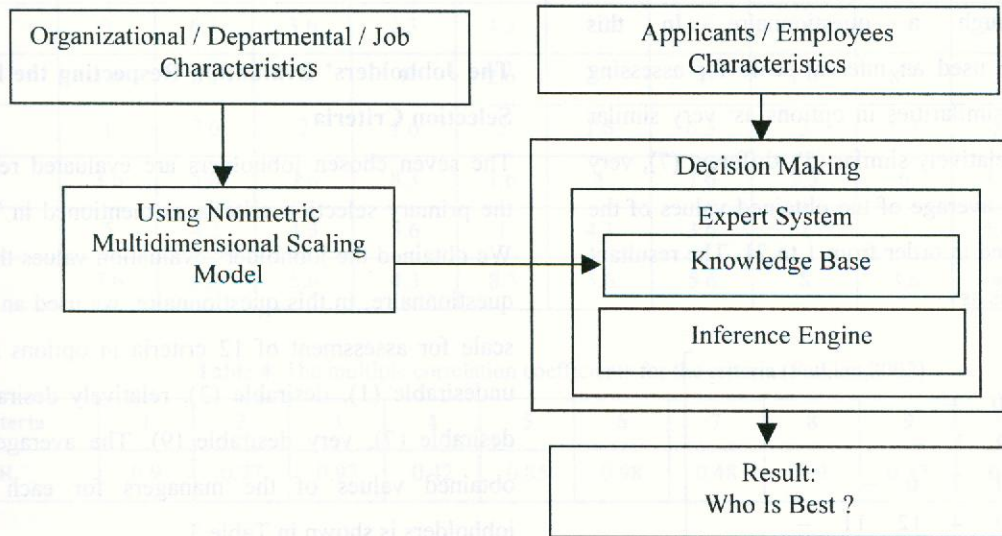
Making the Knowledge Base for the Expert System

The process of building an expert system is called knowledge engineering and is done by a knowledge engineer (Michie, 1973). Making the knowledge base and selection of knowledge representation technique is a very essential part in knowledge engineering. Use of rules and frames for knowledge representation in the

selection process of human resource management is the best (Byun,& Suh, 1996). In this research work representation for developing a model is used. For this purpose, the basic selection criteria according to the mental

structure of the experts are extracted such as that explained in the previous stages. In other words, we use nonmetric MDS for building the knowledge base (as shown in Figure 1).

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┌─────────────────────────────┐        ┌─────────────────────────────┐
│ Organizational / Departmental│        │   Applicants / Employees     │
│     / Job Characteristics     │        │       Characteristics        │
└──────────────┬──────────────┘        └──────────────┬──────────────┘
               │                                        │
               ▼                                        ▼
   ┌─────────────────────┐          ┌──────────────────────────────────┐
   │   Using Nonmetric   │          │        Decision Making            │
   │  Multidimensional   │ ───────▶ │  ┌────────────────────────────┐  │
   │    Scaling Model    │          │  │       Expert System         │  │
   └─────────────────────┘          │  │  ┌──────────────────────┐  │  │
                                     │  │  │   Knowledge Base      │  │  │
                                     │  │  └──────────────────────┘  │  │
                                     │  │  ┌──────────────────────┐  │  │
                                     │  │  │   Inference Engine    │  │  │
                                     │  │  └──────────────────────┘  │  │
                                     │  └────────────────────────────┘  │
                                     └──────────────┬───────────────────┘
                                                    ▼
                                        ┌───────────────────────┐
                                        │       Result:          │
                                        │     Who Is Best ?      │
                                        └───────────────────────┘
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Figure 1 Intelligent Selection Process

Using the Model in an R&D Organization

For the better explanation, we represent some results of the model implementation in a research and development (R&D) organization. The R&D jobs include activities and tasks, which have a great variety of nature with a low analyzability (Triandis & Jain, 1996).The considered organization had about 50 R&D jobs such as: Electronic Expert, Senior Electronic Expert, Electronic Technician and so on. With regard to

the stages explained in the previous part, for one of the organizational jobs we had the following results.

Determination of the Primary Selection Criteria

Completed interviews in the organization regarding the job under consideration were conducive to the determination of primary selection criteria as shown in Table 2.

Table 2 Twelve primary selection criteria for the considered job (Fathian,2002).

Row	Criteria	Row	Criteria
1	Computer skills	7	Self confidence
2	Communication skills	8	Responsibility
3	Problem solving ability	9	Flexibility
4	Management skills	10	Teamwork ability
5	Research ability	11	Creativity
6	Design skills	12	Discipline

Obtaining Proximities

For the job being considered, we chose seven jobholders who had work experience greater than two years. For obtaining the proximity matrix, we calculated the performance similarity value between each pair of the jobholders through a questionnaire. In this questionnaire, we used an interval scale for assessing the performance similarities in options as: very similar (1), similar (3), relatively similar (5), different (7), very different (9). The average of the obtained values of the experts is converted in order from 1 to 21. The resultant proximity matrix is as:

$$
P = \begin{array}{c}
1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7
\end{array}
\begin{bmatrix}
- & & & & & & \\
20 & - & & & & & \\
19 & 1 & - & & & & \\
21 & 7 & 6 & - & & & \\
10 & 4 & 12 & 11 & - & & \\
8 & 14 & 2 & 15 & 5 & - & \\
9 & 3 & 17 & 16 & 13 & 18 & -
\end{bmatrix}
$$

Since the value p_{32} is equal to one, so, the maximum similarity is between the second and third jobholders. The minimum similarity is between the first and forth jobholders too.

Solving the Nonmetric MDS

Statistica is a comprehensive package for statistics that includes an MDS module. By using the proximity matrix in Statistica's MDS module, we obtain the following configuration in two dimensions.

$$
\begin{array}{c}
1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7
\end{array}
\begin{array}{cc}
X & Y \\
\begin{bmatrix}
1.28117 & -0.087346 \\
-0.49524 & 0.628759 \\
-0.64050 & -0.616023 \\
-1.23081 & 0.101812 \\
0.12918 & -0.022519 \\
0.39660 & -0.979004 \\
0.55959 & 0.974321
\end{bmatrix}
\end{array}
$$

The result configuration matrix

The stress of the above configuration is almost 5%, therefore we don't have to consider higher dimensionality. This configuration represents the geometric space of the hidden mental structure of the experts as shown in Figure 2.

The Jobholders' Evaluation Respecting the Primary Selection Criteria

The seven chosen jobholders are evaluated respecting the primary selection criteria as mentioned in Table 2. We obtained the jobholders evaluation values through a questionnaire. In this questionnaire, we used an interval scale for assessment of 12 criteria in options as: very undesirable (1), desirable (3), relatively desirable (5), desirable (7), very desirable (9). The average of the obtained values of the managers for each of the jobholders is shown in Table 3.

The Use of Linear Multiple Regression for Extraction of the Basic Criteria

By using the Statistica's multiple regression module, we perform a linear multiple regression in which the jobholder's evaluation values respecting the primary criteria (as shown in Table 3) work as the dependent variables and the coordinates of the configuration as the independent variables. The multiple correlation coefficients (R) for the primary selection criteria are as shown in Table 4.
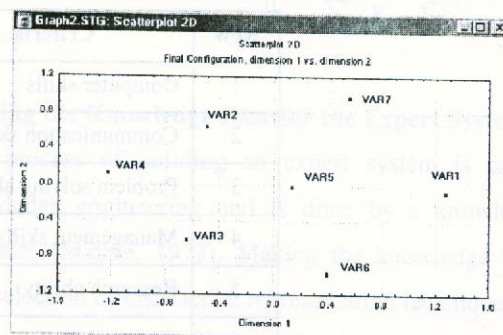
Figure 2 Two-dimensional configuration for the nonmetric MDS

Table 3 The results of the jobholders' evaluation (Fathian,2002).

Persons	Criteria											
	1	2	3	4	5	6	7	8	9	10	11	12
1	5.6	1.6	6	3	2	6.3	2	1	7.6	2.3	2.3	6
2	2	6.3	3.6	2.3	4.3	2.3	3.6	5.6	5.6	3.6	8.3	2
3	1.6	2.3	3	1	2.6	2.3	4	1.6	8.3	3	2	6.3
4	1	7.6	2	1.6	5	1.6	6.3	3	6.3	5	3.2	3.6
5	3.6	5.6	3.6	8.3	1.6	4	7.6	2.3	6	4.3	3	4.3
6	5	4.3	4.3	3.6	1	4.3	3.6	1	4	5.6	1	3
7	7.6	8.3	5.6	4.3	8.3	5.6	5.6	8	3.6	4	7	4.3

Table 4 The multiple correlation coefficients for the criteria (Fathian,2002).

Criteria	1	2	3	4	5	6	7	8	9	10	11	12
R	0.9	0.77	0.97	0.42	0.85	0.98	0.48	0.9	0.37	0.4	0.9	0.4

Therefore, it is shown that only six criteria 1,3,5,6,8 and 11 give significant regression. In other words only these criteria affect the similarity judgments of the experts and they are the basic criteria for employee selection in the job under consideration. We repeated the above stages for obtaining the basic criteria for employee selection in the other R & D jobs.

Making the Knowledge Base for the Expert System

We use the basic criteria that were extracted in the previous part, for development of an intelligent selection process by an expert system. For this purpose, we have the following steps.

1. Determination of the required minimum each of the basic criteria for all the jobs and also the relative weight of them by interviewing the experts within the organization.

2. Extraction of logical rules that define required relations between applicant and vacancy or between employee and job and other logical relations for making the knowledge base of the expert system by

using the results of the previous step.

3. Selecting a shell suitable for implementing the expert system.

In this research work, we developed a rule-based expert system using the CLIPS shell. The required knowledge and expertise for reasoning can be created by the CLIPS constructs, such as DEFTEMPLATE, DEFRULE and DEFFACTS (Giarratano & Riley, 1994).

4. Test and verification of the expert system on real problems in the organization by knowledge engineers and experts.

Information forms can collect input data for the expert system. Since validity of the input data is very important for correct decision-making, therefore an extreme care must be exercised for designing the forms. Job applicants fill out the form and then the obtained data are applied to the expert system.

After running the program (expert system), we need the results and recommendations, therefore these results is saved in an output file for subsequent use.

Conclusion

In this research work, we proposed an effective model for employee selection. The model is meant to extract the basic criteria in the selection of suitable applicants for the organizational jobs with regard to the mental structure of the managers and the experts. These criteria are used for making an effective knowledge base in an intelligent selection process.

The use of intelligent methods for decision-making in different branches of human resource management has a high value especially in today's organizations. In this research work, we have developed an expert system for employee selection. Some of the important features of this system are the flexible and valid knowledge base and resulting ability for the presentation of explanations about the reasonings and decisions that are made.

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