Individual Job Assignment using the Qualification Matrix

S.KHANMOHAMMADI, A.HAJIHA, J.JASSBI System Department I.A. University, Science & Research campus Poonak Sq. Ashrafi Esfahani Blv., Hesarak, Tehran, Iran IRAN

Abstract: -The design of a mathematical model for evaluating and selecting suitable individuals for different jobs, as an optimal assignment problem, is usually one of the critical problems of managers of different organizations.

In this paper a qualification matrix is introduced and is used to classify and select the qualified individuals for different jobs to optimize the man power of the organization. In the introduce methodology different job qualification functions are developed based on questionnaires filled by experts for standard job characteristics. Then the qualifications of different individuals are calculated based on the differences between the scores obtained by job applicants and the standard scores for different behavioral features by using the job qualification functions. The qualification matrix is used by a linear assignment technique to select qualified individuals for different jobs.

Key-words: - Linear assignment, Qualification matrix, Job qualification function, Behavioral feature

1 Introduction

Within the past decade, due to different capabilities of computers, the management researches are more and more attracted with the application of techniques based on mathematical models to increase the reliability of process of decision making and finding optimal solutions for different management problems which, were usually being solved by qualitative methods. Many management researchers have worked on finding different algorithms and models as well as suitable criteria for selecting appropriate individuals for different jobs [1, 2]. In doing so, they have carried out this issue from different view points such as employment, recruiting (seeking employees). employment conditions, human resources planning, etc. In this regard, optimal use of human resources, as the most valuable capitals of the organization, has always been the concern of management scientists. It is quite usual to escalate productivity in man power through training of employees and by using other human resource management strategies which are usually based on qualitative models while the quantitative models are being less used.

In this paper a mathematical model is introduced to process the evaluation scores of behavioral features of individuals for calculating the merits of individuals for each job. In the first step, the indices required for evaluating the behavioral features of the applicants are specified through a systematic method. Then the standard job behavioral identification form is drawn up with the help of experts by analyzing every job using selective behavioral indices. Next, the behavioral indices of the applicants are evaluated through relevant behavioral tests, and then the results are compared with every standard job identification form. Finally the appropriate assignment of individuals for different jobs can be achieved based on the merits or qualifications of individuals.

2 Recognizing and explaining behavioral features

In this work some main indices, are considered as the behavioral features based on a comprehensive study and review of literature of issue [3]. These indices and their definitions are represented in table 1.

Behavioral	Definition
feature (Index)	
Classification	Capability to classifing issues,
capability	objects and events using common
	characters
Logical	Capability to determine logical
relations	relations between issues
Geometrical	Capability to determine
conditions	geometrical conditions on maps
	and pictures
Logical	Voluntary and active
matrices	compatibility with new and
	innovative situations

Table 1. Behavioral indices

Similarity	Ability to detect similarities
detection	between pictures
Conformity	Ability to more quick conformity
speed	on simple issues
Short term	Ability to quickly memorize
memory	required information
Long term	Ability to remember stored
memory	information
Memory	Ability to memorize a great
capacity	amount of information
Creativity	Ability to find solutions, ideas
	and making new innovative
	concepts

2.1 Determining the standard values of behavioral features for different jobs

This section deals with determining the standard values of behavioral features required for different jobs by referring experts. In an oral interview, every interviewee was asked to score standard values in the range [0, 1] for behavioral features required for different jobs. Table 2 shows a typical questionnaire containing some indices and jobs which will be filled by any interviewee.

 Table 2. Jobs and behavioral features

Job Behavioral feature	J ₁ Accountant	J ₂ Computer programmer		Jn
I ₁ Classification capability	a ₁₁	a ₁₂		a _{ln}
I ₂ logical relations	a ₂₁	a ₂₂		a _{2n}
· · · · ·			a _{ij}	
I _m				a _{mn}

The mean values of scores suggested by different experts can be defined by using equation (1).

$$S_{ij} = \frac{\sum_{k=1}^{R} a_{ijk}}{R} \tag{1}$$

Where a_{ijk} represents the standard score of the ith index for the jth job suggested by the kth interviewee, s_{ij} is the mean value for standard score of the ith behavioral feature (index) for the jth job, R is the number of interviewees. These standard scores are used to define the functional relations between the merits of individuals and their obtained scores on different indices for each job as introduced in the next section.

2.2 Functional relation between scores of individuals and their merits

In the oral interview, every expert was also asked to suggest a functional relation between merits and behavioral features for different jobs. Results show that the stronger the relation between job and behavioral feature, the high job satisfaction will be [4]. In this regard three beta shape, tangent hyperbolic, and bell shape functions were used [5, 6]. Every expert was asked to suggest one of these functions as the functional relation between scores of individuals and their merits for the specified job. The most suggested functions are then considered as the functional relations.

The beta shape function can be represented by equation (2), [7]. Where $p \in [0,1]$ is the score of behavioral feature gained by individuals, s indicates the standard score for the job's behavioral feature. $\beta \in [0,1]$ is a parameter that determines the slops of the curve and *q* is the merit (qualification value) of every individual based on his/her score p as shown in figure (1).

$$q = \frac{x^{\beta s} (1-p)^{\beta(1-s)}}{s^{\beta s} (1-s)^{\beta(1-s)}}$$
(2)



Fig.1 Beta shape functional relation between score and merit

It is noted that every score less than the standard score (under qualified) or greater than it (over qualified) will cause a merit of less than unity.

Figure (2) represents a tangent hyperbolic function defined by equation (3), [6]. Where normal is the

normalization function to map the tanh(p-s) to range [0, 1], $p \in [0,1]$ is the score of behavioral feature gained by individual, s indicates the standard score for the job's behavioral feature and q is the merit of every individual based on his/her score p as shown in figure 2.

$$q = Normal(\tanh(p-s)) \tag{3}$$

Note that in this case only the under qualified scores cause the merit less than unity and there is no over qualification.



Fig.2 Normalized tangent hyperbolic functional relation between score and merit

Figure (3) represents a bell shape function defined by equation (4). Where $p \in [0,1]$ is the score of behavioral feature gained by individuals, s indicates the standard score for the job's behavioral feature, *d* determines the shape of the function and *q* is the merit of every individual based on his/her score *p*.

$$q = \frac{1}{1 + d(p - s)^2}$$
(4)

In this figure the scores with the same distances from the standard score (under qualified or over qualified) will cause the same merits less than unity.



Fig.3 Bell shape functional relation between score and merit

The methodology of assigning the appropriate individuals for each job is summarized in the following Algorithm.

Algorithm

- 1. Determining the standard values of behavioral features for different jobs by using the arithmetic mean or any other method, using the data gathered from different interviewees and generate the matrix of standard scores $S=[s_{ij}]$, where s_{ij} denotes the standard score of the ith index for the jth job.
- Use the standard scores s_{ij} to define the functional relations between the merits of individuals and their obtained scores on different indices for each job based on the shapes suggested by different interviewees.
- 3. Generate the matrices of individuals' scores for different behavioral features obtained by applicants for each job k, $P^{k} = [p_{ij}^{k}]$. Where p_{ij}^{k} represents the score gained by the jth applicant for the ith index of the kth job.
- 4. Generate the matrices of individuals' merits of applicants for different indices of each job k, $Q^k = [q_{ji}{}^k]$. Where $q_{ji}{}^k$ represents the merit of jth applicant for the ith index of the kth job.
- 5. Calculate the mean values of merits of different indices for each applicant for each job and generate the total qualification matrix $T=[t_{ij}]$, where t_{ij} represents the qualification value of the jth applicant for the ith job.
- 6. Use the following linear assignment procedure to assign the appropriate individual (applicant) for each job [8].

$$\begin{aligned} MaxmizeZ &= \sum_{i=1}^{m} \sum_{j=1}^{n} t_{ij} x_{ij} \\ &\sum_{i=1}^{m} x_{ij} = 1 \quad , \qquad i = 1, 2, ..., m \\ &\sum_{j=1}^{n} x_{ij} = 1 \quad , \qquad j = 1, 2, ..., n \\ &x_{ij} \in \{0, 1\} \end{aligned}$$

Where $x_{ij} = 1$ means that the ith individual is assigned to the jth job.

3 Case study

In this section some information obtained from an auto after sales services company was used to calculate the merits of eight job applicants for six jobs. Ten indices are considered for evaluation of the applicants for jobs.

The standard values of behavioral features and the shapes of qualification function suggested by experts are represented by tables 3 and 4 respectively.

	J_i I_j	J_1	J_2	J ₃	J_4	J_5	J ₆
	I ₁	0.85	0.70	0.85	0.45	0.95	0.70
	I ₂	0.85	0.50	0.90	0.50	0.95	0.50
	I ₃	0.50	0.40	0.45	0.60	0.80	0.50
	I_4	0.80	0.50	0.80	0.45	0.95	0.50
S=	I ₅	0.95	0.60	0.85	0.95	0.80	0.75
	I ₆	0.85	0.65	0.90	1.00	0.80	0.75
	I_7	0.70	0.55	0.85	0.50	0.80	0.70
	I ₈	0.80	0.55	0.95	0.65	0.85	0.80
	I9	0.75	0.50	0.95	0.60	0.85	0.75
	I ₁₀	0.65	0.50	0.90	0.40	0.90	0.50

Table 3. Standard scores of 10 behavioral featuresfor six jobs

Table 4. Functional relations between merits and
scores

J_i I_j	J_1	J_2	J ₃	J_4	J_5	J ₆
I ₁	Bell	Beta	Bell	Bell	Tanh	Beta
I ₂	Bell	Bell	Bell	Bell	Tanh	Bell
I ₃	Bell	Bell	Bell	Bell	Tanh	Bell
I ₄	Bell	Bell	Bell	Bell	Tanh	Bell
I ₅	Tanh	Bell	Bell	Tanh	Tanh	Bell
I ₆	Tanh	Bell	Bell	Tanh	Tanh	Bell
I ₇	Bell	Bell	Tanh	Bell	Tanh	Beta
I ₈	Bell	Bell	Tanh	Beta	Tanh	Beta
I9	Bell	Bell	Tanh	Beta	Tanh	Beta
I ₁₀	Bell	Bell	Bell	Bell	Tanh	Bell

Figure (4) shows the graphical representation of the functional relations of Table 6.



Fig. 4 Graphical representation of functional relations for different indexes of the 6 jobs

The scores obtained by the eight applicants, based on the relevant tests for the ten behavioral features of the first job are represented in table 5.

	P I	P_1	P ₂	P ₃	P_4	P ₅	P_6	P ₇	P ₈
	I ₁	.86	.43	.50	.79	.36	.64	.50	.59
	I ₂	.77	.54	.54	.77	.31	.61	.46	.38
	I ₃	.70	.50	.50	.60	.30	.50	.50	.50
D –	I_4	.69	.61	.54	.61	.38	.61	.61	.54
r ₁ =	I ₅	.85	.69	.70	.85	.50	.85	.80	.80
	I ₆	.95	.80	.85	1.0	.70	.90	.70	.70
	I ₇	.80	.60	.60	.70	.40	.70	.50	.50
	I ₈	.92	.92	.76	.80	.36	.88	.69	.60
	I9	.84	.72	.60	.80	.32	.76	.56	.52
	I ₁₀	.60	.20	.10	.60	.00	.20	.20	.10

Table 5. Scores for ten behavioral features, obtained by the eight applicants for the first job

Table 6 represents the merits of the eight job candidates regarding the ten behavioral features for the first job.

Table 6. Merits of the eight job candidates regarding the ten behavioral features for the first job

	P I	P ₁	P ₂	P ₃	P ₄	P ₅	P_6	P ₇	P ₈
	I ₁	1.0	.25	.45	.98	.03	.79	.45	.83
	I ₂	.97	.56	.56	.97	0.0	.73	.34	.10
	I ₃	.81	1.0	1.0	.95	.81	1.0	1.0	1.0
	I_4	.94	.83	.68	.83	.25	.83	.83	.68
$Q_1 =$	I ₅	.99	.93	.94	.99	.57	.99	.98	.98
	I ₆	1.0	.99	.99	1.0	.97	1.0	.97	.97
	I ₇	.95	.95	.95	1.0	.59	1.0	.80	.80
	I ₈	.93	93	.99	1.0	.19	.97	.94	.81
	I ₉	.96	1.0	.89	.99	.22	1.0	.83	.75
	I ₁₀	.99	.16	0.0	.99	0.0	.16	.16	0.0

The merits of applicants for other jobs are calculated in the same manner (step 4 of the algorithm).

The mean values of merits of different indices for each applicant on each job are then calculated and the total qualification matrix $T=[t_{ii}]$ is generated as:

	P	P ₁	P ₂	P ₃	P ₄	P ₅	P ₆	P ₇	P ₈
	J_1	.95	.76	.75	.97	.36	.85	.73	.68
т_	J_2	.67	.81	.85	.76	.77	.79	.89	.89
1-	J ₃	.91	.72	.71	.91	.32	.81	.66	.63
	J_4	.69	.87	.92	.81	.74	.85	.95	.92
	J_5	.97	.76	.75	.95	.35	.83	.72	.69
	J_6	.83	.87	.88	.90	.60	.91	.88	.85

Finally using the linear assignment procedure of the 6th step the following linear assignment matrix AM will be generated as:

AM=	P J	P ₁	P ₂	P ₃	P ₄	P ₅	P ₆	P ₇	P ₈
	J ₁	0	0	0	1	0	0	0	0
	J_2	0	0	0	0	0	0	0	1
	J ₃	0	0	0	0	0	1	0	0
	J_4	0	0	0	0	0	0	1	0
	J_5	1	0	0	0	0	0	0	0
	J ₆	0	0	1	0	0	0	0	0

Indicating that:

Individual 1 is assigned to job 5

Individual 3 is assigned to job 6 Individual 4 is assigned to job 1

Individual 6 is assigned to job 3

Individual 7 is assigned to job 4

Individual 8 is assigned to job 2

And individuals 2 and 5 are not assigned to any job.

4 Conclusion

A qualification matrix T is introduced and used to classify and select the qualified individuals to different jobs to optimize the man power. In the introduce methodology different job qualification functions representing standard job characteristics are developed based on questionnaires filled by experts. The merits of different individuals considering different behavioral features are calculated for each job based on the functional qualifications. Three basic job qualification functions namely Bell shape, Beta shape and Tangent hyperbolic shape functions are considered based on suggestions of experts for this The final qualifications of different purpose. individuals are calculated and filled in the qualification matrix and finally the linear assignment procedure is used to select the appropriate individuals for different jobs.

The introduced model in this paper can be used for many applicable problems in different fields such as managerial problems, optimal selection, distribution systems, transportation systems, etc.

References:

[1] A. Volgenant, A note on the assignment problem with seniority and job priority constraints, *European journal of operational research*, Vol.154, No.1, 2004, pp. 330-335.

[2] Juan D. Carrillo, Job assignments as a screening device, *International journal of industrial organization*, Vol.154, No.1, 2002, pp. 330-335.

[3] R.B. Cattell, Personality pinned down, *Psychology today*, 1973, pp. 40-46.

[4] D.C. Feldman & H.J. Arnold, Personality types and career patterns: some empirical evidence on Holland's model, *Canadian journal of administrative science*, 1985, pp. 192-210.

[5] Athanasios Papoulis & S. Unnikrishna Pillai, Probability, random variables and stochastic processes, McGraw-hill, 4th Edition, 2002. [6] Averill Law & David Kelton, Simulation modeling and analysis Industrial engineering and Management Science Series, McGraw-hill, 3rd Edition, 2003.

[7] S. khanmohammadi, I. Hassanzadeh & H. R. Zarei Poor, Fault diagnosis probabilistic neural network with beta distributed weights of connections, proceedings of the second international computer science conventions symposium on engineering of intelligent systems, pp 79-84, June 2000, Scotland, U.K.

[8] Gerard M. Campbel and Moustapha Diaby, Development and evaluation of an assignment heuristic for allocating cross trained workers, *European journal of operational research*, Vol.138, No.1, 2002, pp. 9-20.