A VIKOR Method for Solving Personnel Training Selection Problem

Mohamed F. El-Santawy

Abstract—The main aim of this paper is to present an effective way of assigning weights to criteria in absence of decision makers’ preference in Multi Criteria Decision Making problems. The Information Entropy Weight method is presented and illustrated for that aim. Personnel training process is essentially needed in developing organizations. It implies more than one dimension to be optimized. Many conflicting criteria should be considered when comparing alternatives to choose among or rank them. In this article a Multi-Criteria Decision Making (MCDM) problem is presented and a real-life international company personnel selection problem of a new manner is illustrated. The VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) method combined to Information Entropy Weight method is presented to solve the MCDM problem.

Index Terms—Information entropy, Multi-criteria decision making, Personnel, VIKOR

I. INTRODUCTION

THE improvement of employees’ knowledge confers a competitive advantage that enhances an organization’s ability to meet customers’ diverse and rapidly changing demands. For most organizations the ability to have the right staff on duty at the right time is a critically important factor when attempting to satisfy their customers’ requirements. Selection of qualified human resources is a key success factor when attempting to satisfy their customers’ requirements. The complexity and importance of the problem call for analytical methods rather than intuitive decisions [5]. There is high interest in analyzing the criteria of selecting personnel for training as well as their educational services provided locally or in other countries. The adequate personnel training has a dramatic effect on improving the employees’ performance, which will be reflected on the growth and competence of the whole organization, especially in large-size and multi-national companies and organizations. Training and education are designed to meet personal needs for knowledge, talents, and skills, as well as the organization’s need for qualified personnel.

Personnel training is defined as the process of constructing optimized courses and studies for a company has received increasing attention over the past few years [2]. Personnel training selection problem is a well known Multi Criteria Decision Making (MCDM) problem which involves many conflicting attributes. The merit of MCDM techniques is that they consider both qualitative parameters as well as the quantitative ones. MCDM includes many solution techniques such as Simple Additive Weighting (SAW), Weighting Product (WP) [4], and Analytic Hierarchy Process (AHP) [10]. The personnel selection problem, from the multi-criteria perspective, has attracted the interest of many scholars as in [8],[9]. In this paper a new personnel training selection problem existed in a multi-national company is presented. The technique named ViseKriterijumska Optimizacija I Kompromisno Resenje in Serbian (VIKOR) is applied to rank the candidates for an international course of one year duration provided by the company to its employees. An Information Entropy Weighting (IEW) method is introduced for the criteria of selection. The rest of this paper is organized as follows: section II is made for the VIKOR approach, section III is devoted to the Information Entropy Weight new method, the case study of the personnel training problem is presented in section IV, and finally section V is made for conclusion.

II. VIKOR

A MCDM problem can be concisely expressed in a matrix format, in which columns indicate criteria (attributes) considered in a given problem; and in which rows list the competing alternatives. Specifically, a MCDM problem with m alternatives (A1, A2, …, Am) that are evaluated by n criteria (C1, C2, …, Cn) can be viewed as a geometric system with m points in n-dimensional space. An element xij of the matrix indicates the performance rating of the ith alternative Ai, with respect to the jth criterion Cj, as shown in (1):

\[
\begin{bmatrix}
    c_1 & c_2 & c_3 & \cdots & c_n \\
    a_1 \begin{bmatrix} x_{11} & x_{12} & x_{13} & \cdots & x_{1n} \end{bmatrix} \\
    a_2 \begin{bmatrix} x_{21} & x_{22} & x_{23} & \cdots & x_{2n} \end{bmatrix} \\
    \vdots & \vdots & \vdots & \ddots & \vdots \\
    a_m \begin{bmatrix} x_{m1} & x_{m2} & x_{m3} & \cdots & x_{mn} \end{bmatrix}
\end{bmatrix}
\]

(1)

The VIKOR method was introduced as an applicable technique to implement within MCDM [6],[7],[11]. It focuses on ranking and selecting from a set of alternatives in the presence of conflicting criteria. The compromise solution, whose foundation was established by Yu [15] and Zeleny [17], is a feasible solution, which is the closest to the ideal, and here “compromise” means an agreement established by mutual concessions. The VIKOR method determines the compromise.
ranking list and the compromise solution by introducing the multi-criteria ranking index based on the particular measure of “closeness” to the “ideal” solution [7]. The multi-criteria measure for compromise ranking is developed from the \(L_p\)-metric used as an aggregating function in a compromise programming method [11]. The levels of regret in VIKOR can be defined as:

\[
L_{pi} = \left\{ \sum_{j=1}^{n} w_j \frac{(x_j^* - x_i^*) / (x_j^* - x_j^*)^{p/p}}{j} \right\}^{1/p}, 1 \leq p \leq \infty ,
\]

(2)

Where \(i = 1, 2, \ldots, m\). \(L_{pi}\) is defined as the maximum group utility, and \(L_{j*}\) is defined as the minimum individual regret of the opponent. The procedure of VIKOR for ranking alternatives can be described as the following steps [3]:

**Step 1:** Determine that best \(x_j^*\) and the worst \(x_j^*\) values of all criterion functions, where \(j = 1, 2, \ldots, n\). If the \(j\)th criterion represents a benefit then \(x_j^* = \max_i f_{ij}\), \(f_{ij} = \min_i f_{ij}\).

**Step 2:** Compute the \(S_j\) (the maximum group utility) and \(R_i\) (the minimum individual regret of the opponent) values, \(i = 1, 2, \ldots, m\), by the relations

\[
S_j = L_{ij} = \sum_{j=1}^{n} w_j \frac{(x_j^* - x_i^*) / (x_j^* - x_j^*)},
\]

(3)

\[
R_i = L_{xij} = \max_j \left\{ \sum_{j=1}^{n} w_j \frac{(x_j^* - x_i^*) / (x_j^* - x_j^*)} \right\},
\]

(4)

where \(w_i\) is the weight of the \(j\)th criterion which expresses the relative importance of criteria.

**Step 3:** Compute the value \(Q_i, i = 1, 2, \ldots, m\), by the relation

\[
Q_i = v(S_i - S^*) / (S^* - S) + (1 - v)(R_i - R^*) / (R^* - R),
\]

(5)

Where \(S^* = \min_i S_i\), \(S^* = \max_i S_i\), \(R^* = \min_i R_i\), \(R^* = \max_i R_i\), and \(v\) is introduced weight of the strategy of \(S_i\) and \(R_i\).

**Step 4:** Rank the alternatives, sorting by the \(S, R\) and \(Q\) values, in decreasing order. The results are three ranking lists.

**Step 5:** Propose as a compromise solution the alternative \((A')\) which is ranked by the best minimum \(Q\) if the following two conditions are satisfied:

**C1.** “Acceptable advantage”:

\(Q(A') = Q(A) \geq DQ\), where \(A'\) is the alternative with second position in the ranking list by \(Q, DQ = 1/(m - 1)\) and \(m\) is the number of alternatives.

**C2.** “Acceptable stability in decision making”:

Alternative \(A'\) must also be the best ranked by \(S\) or/and \(R\). This compromise solution is stable within a decision making process, which could be: “voting by majority rule” (when \(v > 0.5\) is needed), or “by consensus” \(v \approx 0.5\), or “with vote” \((v < 0.5)\). Here, \(v\) is the weight of the decision making strategy “the majority of criteria” (or “the maximum group utility”). \(v = 0.5\) is used in this paper. If one of the conditions is not satisfied, then a set of compromise solutions is proposed [3].

Recently, VIKOR has been widely applied for dealing with MCDM problems of various fields, such as location selection [12], environmental policy [13], and data envelopment analysis [14].

**III. INFORMATION ENTROPY WEIGHT**

The weight of the criterion reflects its importance in MCDM. In this paper, an objective weight is applied; named Information Entropy Weight (IEW) based on the information entropy of raw data [1], [16]. Based on the decision matrix \((D)\) shown in (1), Range standardization is done to transform different scales and units among various criteria into common measurable units in order to compare their weights.

\[
x_{ij}' = x_{ij} - \max_{1 \leq j \leq n} x_{ij} - \min_{1 \leq j \leq n} x_{ij}
\]

(6)

\(D' = (x')_{max}\) is the matrix after range standardization; \(\max x_{ip}\), \(\min x_{ij}\) are the maximum and the minimum values of the criterion \((j)\) respectively, all values in \(D'\) are \((0 \leq x_{ij}' \leq 1)\). So, according to the normalized matrix \(D' = (x')_{max}\) the information entropy is calculated as shown in the following steps, first in order to avoid the insignificance of \(\ln f_{ij}\) in (8) \(f_{ij}\) is stipulated as shown in (7):

\[
F_{ij} = \frac{1 + x_{ij}'}{\sum_{i=1}^{n} (1 + x_{ij}')}
\]

(7)

\[
H_j = - \left( \sum_{i=1}^{m} f_{ij} \ln f_{ij} \right) i = 1, 2, \ldots, m; j = 1, 2, \ldots, n
\]

(8)

After calculating the variation degree \((H_j)\), the deviation degree of the criterion \((j)\) noted by \((G_j)\) is computed as in (9)

\[
G_j = 1 - H_j\quad j = 1, 2, \ldots, n
\]

(9)

It is obvious that \((G_j)\) is greater if the value of \((H_j)\) is smaller, consequently if the \((G_j)\) is higher, the information entropy \((H_j)\) is lower, which indicates that the more the information criterion \((j)\) provides, the greater weight given to the criterion \((j)\). The weight \((W_j)\) of the criterion \((j)\) is defined as:

\[
W_j = \frac{G_j}{\sum_{j=1}^{m} G_j} = \frac{1 - H_j}{n - \sum_{j=1}^{n} H_j}
\]

(10)

Where \(j = 1, 2, \ldots, n\)

**IV. CASE STUDY**

A multi-national company that works in Tele-Communications is willing to select two employees from its personnel to join a one-year course provided by one of its suppliers in Europe. The course is budgeted by 200,000 Euros for one person; the supplier company will pay the fees, and the whole charges of
the two employees suggested by the multi-national company in order to train and teach the rest of the company during the orientation phase after the supplier company installs and provides its software packages. The company restricted the selection to middle management in the technical support department found in the whole company branches and offices. After many procedures and tests done, six candidates are eligible to have the opportunity of the course, the multi-national company Human Resources department specifies five criteria to compare the six candidates and put them through many tests for them in order to select only two. The process of ranking the six candidates in order to select optimally two is a typical MCDM problem.

The Human Resources department set two exams to the six candidates; first the fluency in the foreign language test was set to be out of 900 points, and the second computer skills test including basic programming and logic concepts to be out of 600 points. The human resources department set the first criterion (C1) to be the age of the candidate, the younger is preferable. C2 is set to be the experience years in the field; C3 is the number of years passed by the candidate inside the company. C4 is the sum of grades obtained by each candidate in the two exams set by Human Resources department. Finally C5 is set for the education background including the graduation, postgraduate studies, and certificates relevant to the course provided. The points are given by the Human Resources department to each candidate. Table I shows the five criteria, and their computation units. The Human Resources department presented the data included in the decision matrix found in Table II showing the 6 candidates, and their performance ratings with respect to all criteria. All candidates are indexed by the term (CAND) for simplicity.

Table V shows the values of the variation degree ($H_j$), the deviation degree ($G_j$), and the weight assigned to each criterion ($W_j$) based on information entropy as in (8), (9), and (10).

By using the procedure of VIKOR, we can calculate the $S$, $R$ and $Q$ values as shown in Table VI to derive the preference ranking of the alternatives, the company should select the second and the third candidates for the training course provided. Both candidates have the minimum $S$, $R$, and $Q$ values, also the two conditions mentioned earlier in section 2 are satisfied.
V. CONCLUSION

A VIKOR method combined to Information Entropy Weight method is presented to solve the MCDM problem. A real-life personnel selection training problem of a new manner is introduced. The VIKOR method is introduced to solve this MCDM problem based on the classical utility function. It might be combined to other techniques in further research. The MCDM problem should be reformulated and solved if any parameter or alternative is added or deleted because of its sensitivity to any changes.

REFERENCES


Mohamed Fathi El-Santawy was born in El-Mohandseen, Giza, Egypt. He received his Bachelor of Commerce and Business Administration at Helwan University, Egypt in 2001, and obtained his diploma and Master degrees in Operations Research at the Institute of Statistical Studies and Research (ISSR), Cairo University in 2006 and 2009. He is now pursuing his PhD degree at the department of Operations Research, Institute of Statistical Studies and Research (ISSR), Cairo University. His current research interest includes Multi-Criteria Decision Making (MCDM), Multi-Objective Evolutionary Algorithms (MOEA), Swarm Intelligence (SI), and Chaos Optimization. He published many articles in the areas of MCDM, Chaos, and MOEA.