Using Fuzzy Wage Management System in Heavy Industry

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Abstract

Structuring an accurate wage management system is one of the most important steps in managerial activities of human resource management. This is based on job evaluation which is used to determine the relative importance of each job in a company. Job evaluation can be defined as a multi-criteria decision making problem. However, the evaluation processes, being subject to the diversity of managers’ assessment are often resulting in pay inequity. This outcome can be circumvented by utilizing a fuzzy job evaluation system. In this study, Analytic Hierarchy Process (AHP) is used to evaluate the specific criteria and fuzzy wage brackets are evaluated by Fuzzy Regression Analysis (FRA) in the steel industry.

Keywords: Job Evaluation, Fuzzy AHP, Multi-Criteria Analysis, Wage Brackets, Fuzzy Regression.

1. Introduction

Job evaluation is a systematic technique that provides the design, structuring, and improvement of human resource management systems. In an organization, many kinds of works available with their specific criteria. The worth of each job has to differ from another in respect of these features [1], this relative worth determination is the subject of job evaluation procedures”.

The most common and maybe the most reliable method is the Point Method in job evaluation. Xing [2] indicated that this method is widely used and achieves more accurate results”. “The seniority, success, and some social expenses are included into the real payment system [3]”.

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“In the studies on recent decades, Spyridakos [4] worked on the multi-criteria job evaluation for large organizations, Dağdeviren [5] used a goal programming models and Xing [2] used Analytic Hierarchy Process (AHP) evaluation for jobs as a managerial decision-making problem with multiple objectives [6]”. Therefore, sequencing and scoring of the aims should be considered in a fuzzy process in natural consequence. The fuzzy logic theory allows mathematical operators and programming be applied in the fuzzy domain. A fuzzy set is a class of objects with separate grades of membership. Such a set is characterized by a membership (characteristic) function, which assigns to each object a grade of membership ranging between zero and one. Many kinds of fuzzy ranking methods for fuzzy numbers have been suggested in past literature. “These methods may be obtained different ranking results and most methods are onerous in graphic operations requiring complex mathematical calculation [7]”.

In this study, the fuzzy AHP method (FAHP), which uses fuzziness in multi-criteria, was used for the job evaluation procedures. In the fuzzy pair-wise comparisons, more accurate weights could be obtained in this conflict of factor scoring and weighting. Then, the fuzzy wage brackets were constructed in the payment system by Fuzzy Regression Analysis (FRA) for a private steel company.

2. Methods

2.1. Fuzzy Analytic Hierarchy Method (FAHP)

The FAHP is provided systematic and robust approaches to the alternative selection and decision problems by using the concepts of fuzzy set theory and hierarchical structure analysis. Decision-makers are usually more confident in giving interval judgments rather than crisp judgments due to the fuzzy nature of the comparison processes.

“The steps of Chang’s [8], [9] extent analysis approach are as follows: Let X={x1, x2,…,xn} be an object set, and U={u1,u2,…,um} be a goal set where each goals are gi’s, respectively”. Thus, m extent analysis values for each object can be obtained.

The steps of Chang’s extent analysis are as follows:

**Step 1:** Define the value of fuzzy synthetic extent with respect to the ith object

**Step 2:** Expressed the degree of possibility of $M_2 = (l_2, m_2, u_2)$ ≥ $M_1 = (l_1, m_1, u_1)$ where l, m, and u are the lower, medium, and upper bounds respectively (See Fig.1)

![Fig.1. Intersection between M1 and M2](image)

**Step 3:** Calculate the degree of possibility for a convex fuzzy number to be greater than k convex fuzzy numbers $M_i$ (i=1,2,...,k)

**Step 4:** Via normalization procedures, obtain the normalized weight vectors.
2.2. Fuzzy Regression Analysis (FRA)

FRA models, in the last years, have been successfully applied to numerous engineering and decision-making problems. Besides, this method can be combined with the fuzzy job evaluation process in the manufacturing and service companies. Additionally, instead of the crisp values in evaluation of the wage brackets, obtaining a fuzzy interval is more relevant to the real life problems which are why the linguistic variables are used most commonly. FRA has been shown to be more flexible and rigorous than the traditional (non-fuzzy) decision-making approaches. It can be applied to problems in which the strict assumptions of statistical regression analysis cannot be met. FRA considers the use of triangular or trapezoidal fuzzy numbers that involves the modelling of problems where the output variable is affected by faulty measurement. The goal of FRA is to find a regression model that fits all observed fuzzy data within a specified fitting criterion.

“The basic model that developed by Tanaka [10] assumes a fuzzy linear regression function defined in Eq.1.”

\[
\Psi_0 = \Psi_0(X_0 + \Psi_0X_1 + \Psi_0X_2 + \ldots + \Psi_0X_n = AX),
\]

where \(X = (X_0, X_1, \ldots, X_n)^T\) is an input vector; \(\Psi_0 = [\Psi_0, \Psi_0, \ldots, \Psi_0]^T\) is a vector of fuzzy coefficients in the form of symmetric triangular fuzzy numbers, \(y_i\)‘s are estimated outputs and \(\Psi_0 = (\alpha_j, c_j)\). “This approach is called as the LP approach in fuzzy regression analysis [11]”. The FRA analysis provides to the following LP problem in Eq.2:

\[
\begin{align*}
\min J &= \sum_{j=1}^{n} \left( c_j \sum_{i=1}^{m} |x_{ij}| \right) \\
\sum_{j=0}^{n} \alpha_j x_{ij} - \alpha_j - h &\sum_{j=0}^{n} c_j |x_{ij}| \leq y_i, \quad i = 1, \ldots, m \\
\alpha_j x_{ij} - \alpha_j - h &\sum_{j=0}^{n} c_j |x_{ij}| \geq y_i, \quad i = 1, \ldots, m \\
c_j &\geq 0, \quad j = 0, \ldots, n, \quad 0 \leq h \leq 1.
\end{align*}
\]

3. Application of the proposed model

In this section, the proposed job evaluation model for heavy industry and the steps of the model are described. For this application, an expert committee was established by service managers and responsible staffs of the company each from each department. The proposed system for steel industry using FAHP method follows the steps below:

Step 1: Identifying the main and subfactors for the model.
The expert committee was decided to use the factors and some sub-factors outlined by the Turkish Trade Union of Metal Industrialists with some extensions consistent to the steel company’s structure. A total of 13 sub-factors are given below organized into five categories; Mastery, Responsibility, Work Load and Physical and Working Conditions:

*Mastery Factors*
- Education/Knowledge
- Experience
- Skill
- Predisposition

*Responsibility Factors*
- Machine/equipment responsibility
- Material/product responsibility
- Production continuity responsibility
- Security providing responsibility

*Workload Factors*
- Mental effort
- Physical effort

*Physical and Working Conditions Factors*
- Job risks
- Working environment
- Protective material necessity

**Step 2: Structuring the FAHP model hierarchy**

The FAHP model is composed of 3 stages. In the first stage, there is the objective of the study for evaluating the jobs. There are factors in the second stage and the sub-factors related to them in the third stage respectively. Then, the evaluation of the jobs with FRA and the structuring of the fuzzy wage brackets are involved the fourth and fifth stages.

**Step 3: Determination of the local and global weights of the factors and sub-factors**

Pair-wise comparison matrices are formed for each category by the decision committee. FAHP scale given in “Table 1” is used. “These matrices are analyzed according to the Chang’s (1996) [9] extend analysis method”. Global weights of sub-factors are calculated by multiplying the local weights of the sub-factors with the local weight of the factor.

<table>
<thead>
<tr>
<th>Table 1. Linguistic scales for difficulty and importance</th>
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<tbody>
<tr>
<td><strong>Linguistic scale</strong></td>
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<tr>
<td>Equal importance</td>
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<tr>
<td>Moderate importance</td>
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<tr>
<td>Strong importance</td>
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<td>Very strong importance</td>
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<td>Demonstrated importance</td>
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</table>
Step 4: Graduation operations for point system

Utilizing the normalized global weights, the grades of the sub-factors are calculated using geometric progression. The coefficient is used as 5 and progression multiplier is calculated as $\sqrt[n-1]{\frac{P_{\text{max}}}{P_{\text{min}}}}$, where $n=5$, $P_{\text{max}}$ and $P_{\text{min}}$ are the maximum and the minimum points of jobs respectively.

Step 5: Evaluation of the jobs by grade points

The 86 jobs of steel company are evaluated using the grades and the scale values, the total points of each job are calculated.

Step 6: Calculation of the points and wage intervals using FRA

The total points are sequenced in ascending order, which are varied between 241 (the minimum) and 592 (the maximum).

The range is divided into 5 intervals (X1 to X5) which have 5-point and 5-wage (Y1 to Y5) variables for using in FRA in respect to the views of the decision committee and the features of the steel sector. The wage intervals of the jobs are decided with respect to the equivalent steel companies in the market which are 600-1000 for X1, 1000-1500 for X2, 1500-2000 for X3, 2000-3000 for X4, and 3000-5000 for X5. The dispersions are given in “Fig.2” for h level is 0.9.

It is evident that the minimum dispersion is at the level of h=0.1 and increasing towards the level of h=0.9. Therefore, the managers of the steel companies are given options to determine the level which is the appropriate plan for their waging policies.

Step 7: Structuring the fuzzy wage brackets
Using the proposed model, it is seen that the job points range is varied 241 points to 592 points. Then, 86 jobs are evaluated in respect to FRA and the wage groups are obtained on the basis of the total points as shown in “Fig. 3”.

In the FRA, instead of crisp wages, fuzzy mathematical estimation model is run to estimate the upper and lower bounds of wages in the brackets. This is the keynote speech of the study. In the conventional system, the managers accepted that the upper and lower bounds are 10% over and 10% below of the estimated average values, respectively. The FRA-based fuzzy wage brackets model is proposed to managers for a convenient wage management system in heavy industry.

![Fig. 3. Fuzzy wage brackets for lower, center, and upper intervals.](image)

4. Conclusion and discussion

Multi-criteria decision making are made today in complex manufacturing systems especially in steel companies. In most cases the use of experts’ view is quite necessary and different measurement systems need to be regarded in human resource management. In many of such decision-making processes the theory of fuzzy decision-making can be easily performed. Using the fuzzy group decision-making can overcome the difficulty of complex environments and systems in waging systems to prevent pay inequity. In general, many concepts, tools and techniques can be used to improve human consistency and implementation of complex models. These decision tools provide more relevant and exact decision making processes.

In the job evaluation, some information required for convenient decision-making which is vague and uncertain in the most situations. It is very difficult to obtain exact or precise assessment data, especially in description of the features of works and jobs and in construction of payment system in human resource information systems. To address this concern, the concepts of fuzzy numbers can be helpful in evaluation of the factors in every level of the planning period.

In this study, job evaluation process is proposed as a multi-criteria decision-making problem under a fuzzy environment, where the exact decision-makers judgments are represented as triangular fuzzy numbers. The FAHP method is used for assessment of the weights, and the points of each job are calculated. To improve the model, FRA-based wage brackets are considered and embedded into evaluation processes calculating the results of the linear mathematical model to estimate the upper and lower bounds. With such an approach, the
subjectiveness of the committee (decision-makers) is reduced and the most appropriate model to the steel companies according to their membership degrees is obtained. The experimental study in the steel company shows the advantages and the usability of the proposed model in distinguishing between the jobs in a sensitive manner especially in determination of the wage brackets and also waging systems.

The proposed FAHP-FRA hybrid model provides a valuable support to heavy industry in decision-making and this approach can be easily applied to each company from different sectors in determining the company’s features according to the evaluation factors and job variety.

On the basis of the calculated job points, 5 different waging groups are constituted between the lower wage bound of TRY600 and upper wage bound of TRY5000. The payment structure is constituted for each worker in respect of the seniority in the brackets. Using the total points, job groups are determined using FRA.

The FRA-based wage brackets model provides the ability to managers to structure a flexible wage management system. Moreover, the powerful structural adjustment process to the new system is obtained. In this way, a new payment management system would be beneficial to the sectors where applicable.

As a future of this study, the relationships between the factors and sub-factors will be regarded in each level, one may consider the Analytical Network Process (ANP), which is a recently proposed method. It is believed that both of the fuzzy ANP and FRA methods could be used to obtain more accurate result in job evaluation and payment systems.

References