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Application of linear regression method in University teacher's performance evaluation

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ABSTRACT

The existing university teachers' performance evaluation system mostly takes the form of questionnaire for truthful data and analytic hierarchy process for evaluation. The data required are demanding and their consistency is scrutinized as well. Basing on small sample data of university teachers' performance evaluation and using the minimum sample deviation of linear regression method to evaluate the model of university teachers' performance evaluation, the author tries to find a more reasonable and scientific method to conduct comprehensive evaluation of university teachers' performance.

KEYWORDS

Linear regression method; University teachers; Performance evaluation.

INTRODUCTION

Higher education in China has entered the popular stage of development, the number and overall quality of teachers has improved greatly. Therefore, to establish a capacity & performance-oriented and scientific social evaluation system is of vital importance to current university reform[1,2]. Universities establish teachers'performance evaluation system[3] to promote the teachers' understanding of themselves and integrated development on the one hand, and to provide the administrative staff with references for evaluating the teachers and achieving reasonable allocation of human resources on the other hand. In the light of a document University Teachers' Performance Evaluation, we establish a model of teachers' performance evaluation

University teachers' performance ought to be evaluated so as to meet the requirements of the information society and universities. In the literature on performance evaluation, the authors mostly adopted the AHP for evaluation——YI Xiao Yu, Huang Huiming who adopted the AHP for the comprehensive quality evaluation of research students and vocational students; WU Bo who adopted the AHP to evaluate the information literacy of primary and secondary school teachers; LI Minghua who adopted the AHP to do research on the performance evaluation system construction of PE academies. The author of this paper also adopted the fuzzy AHP to study the issue of university teachers'performance evaluation[4]. In the AHP analysis the requirements to data are demanding and repeated consistency tests are necessary, so the author tries to find a fresh method for university teachers' performance evaluation.

Conventional method of evaluating teachers' performance focuses on determining the structure model of evaluation system and the weights of various evaluating indexes. Its practical steps are as follows: firstly, determining the structure model and the weights of related indexes based on the discussions of relevant experts; secondly, grading a teacher by such three groups as the leadership, the peer teachers and the students, and calculating all the scores by combining the weights of various indexes; and finally obtaining the final evaluation score by integrating the scores with the weights at these three groups. Hence, this system of teachers' performance evaluation is linear or almost linear.

GUO Cheng, who once applied multivariant linear regression method in evaluating the invisible benefits of IT project, holds that this method will help an enterprise to achieve more objective and real evaluation of its project' potential value and will be of significance to be popularized in evaluating the invisible benefits of other projects. LANG Qiuling once applied multivariant linear regression method in the zoning and evaluation of the mudslides in ditches of some certain region, whose evaluation result is consistent with this region's disaster situation and provides relevant departments with a scientific basis for mudslides prevention and control planning. GU Xingrong once applied multivariant linear regression method in the research on indexes of economic development and achieved good results. PENG Ruixia & Xu Ru once applied multivariant linear regression method in constructing an evaluation system of teachers' information literacy. All these researches are literature basis for the author of this paper to build his evaluation system of university teachers' performance with the aid of multivariant linear regression method.

Linear regression method is a commonly used mathematical method, in which a controllable independent variable X is given a certain value and then the dependent variable Y acquires a random value. Repeating n times, we will obtain n pairs of numbers: (X1, Y1), (X2, Y2),..., (Xn, Yn), and then we may conduct linear regression analysis.

Linear Regression Analysis has such characteristics as[5]: flexibility——it may build dynamic weight distribution in accordance with different evaluation systems of indexes; reliability—— as its samples are real, excluding those subjective factors in questionnaire, the calculated weight results are objective, scientific and rational; practicability——its repeated weight calculation process is done by computer, easy to operate and time-saving.

As to those already established evaluation models of teachers' performance, the author tries to build relevant mathematical models based on real data analysis, conducting regression analysis with the method of least squares and then obtaining the weight matrix, to study related evaluation system of teachers' performance.

LINEAR REGRESSION METHOD

Suppose Y as the dependent variable, and X1, X2... Xp as the independent variables, and the independent variables and the dependent variable are of linear relationship, then the multivariant linear regression model is: $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 \ldots + \beta_p X_p + \varepsilon$, in which $\beta_0, \beta_1, \ldots, \beta_p$ are p+1 indeterminate parameters, β_0 is a constant term, $X_1, X_2, \ldots X_p$ are regression coefficients, ε is residual error.

If offered a set of sample data, we can obtain the estimated values of indeterminate parameters $b_0, b_1 \ldots b_p$, and then get following regression equation:

$$\hat{y}_i = b_0 + b_1 X_1 + b_2 X_2 + ... + b_p X_p$$

Thus, the process of building the regression equation is the process of estimating the values of parameters including constant terms and regression coefficients.

DETERMINE THE WEIGHTS OF INDEXES

First, establish questionnaire based on the indicator system shown in Figure 1 to obtain *n* groups of sample data, in which evaluation indexes are: $A_k\left(0<\mathrm{k}\le 5\right)$, $M_k\left(0<\mathrm{k}\le 5\right)$referring to the number of indicator A_k ; the quantitative indicator is $\mu_{ij}(0<\mathrm{i}<=\mathrm{N},\ 0<\mathrm{j}\le \mathrm{M}_k, 0\le\mu_{ij}\le 1)$, indicating the No. j quantitative indicator of evaluation indicator A_k in No. i sample data; Q_i refers to the mean of all quantitative indexes of evaluation indicator A_k in No. i sample data; observed indicator is $B_k\left(0<\mathrm{k}\le 5\right)$. Weight of evaluation indexes is $\alpha_k\left(0<\mathrm{k}\le 5\right)$, mean square deviation is $\sigma_k\left(0<\mathrm{k}\le 5\right)$. In light of the definition of regression analysis, we obtain:

$$A_k \square X = B_k \tag{1}$$

$$Q_i = \frac{1}{M_k}\sum_{j=1}^{M_k}\mu_{ij} \tag{2}$$

$$A_k = \begin{bmatrix} \mu_{11} & \mu_{12}\cdots & \mu_{1j} & \cdots & \mu_{1M_k} \\ \cdots & & & \cdots & \\ \mu_{i1} & \mu_{i2}\cdots & \mu_{ij} & \cdots & \mu_{iM_k} \\ \cdots & & & \cdots & \\ \mu_{N1} & \mu_{N2}\cdots & \mu_{Nj} & \cdots & \mu_{NM_k} \end{bmatrix},\ B_k = \begin{bmatrix} Q_1 \\ ... \\ Q_i \\ ... \\ Q_N \end{bmatrix} \tag{3}$$

Put equations (2) and (3) into equation (1), and by making use of least square method we get the weight of evaluation indexes:

$$\alpha_k = \begin{bmatrix} \alpha_{k1} \\ \cdots \\ \alpha_{kj} \\ \cdots \\ \alpha_{kM_k} \end{bmatrix} \tag{4}$$

In actual calculations, the samples we obtain about teachers' information far outnumber the weights, so our task is to find the value of X which enables $\sigma_k = \left|A_k \square X - B_k\right|$ to be the minimum.

ESTABLISH THE SETOF EVALUATION PROGRAMS

Conventionally, the comprehensive evaluation system consists of four grades {poor, common, good, and excellent}. Establish the set of evaluation V = (v1, v2, v3, v4) = {0.25, 0.5, 0.75, 1} in accordance with these four grades. Based on the principle of maximum membership grade, we obtain the results through classifying these indicator weight matrices.

OBTAIN 20 GROUPS OF SAMPLE DATA

Based on the questionnaire, we randomly select 20 groups of sample data, with each group including 5 teaching indexes (teaching workload, teaching attitude, teaching innovation, teaching skills, teaching results), 3 research indexes (research projects, research papers, scientific achievement transformation), 5 indexes on students cultivation (thesis

instruction, social practice instruction, students' operation ability, curriculum design instruction), 3 indexes on discipline construction (discipline planning, academic exchange, talent introduction),and 5 other indexes (student work, charity work, Acad. part-time job, academic judges, T&R activities), totalling 20 * 21 data. Take the teaching indexes B1 as example, 20 groups of sample data are shown in TABLE 1 below:

TABLE 1 : 20 groups of sample data as to teaching indexes

Sample data	Teaching workload	Teaching attitude	Teaching Innovation	Teaching skills	Teaching results
1	0.8	1.0	0.3	0.8	0.9
2	1.0	1.0	0.2	0.9	1.0
3	0.7	0.8	0.5	0.8	1.0
4	0.9	0.9	0.4	0.8	0.9
5	0.6	0.9	0.1	0.8	1.0
6	0.6	0.9	0.5	1.0	0.7
7	0.8	0.8	0.2	0.6	0.7
8	0.9	0.7	0.7	0.8	0.9
9	0.6	0.9	0.6	0.8	1.0
10	0.9	1.0	0.6	0.7	0.9
11	0.6	0.9	0.5	0.8	1.0
12	0.9	0.8	0.5	0.8	0.9
13	0.8	0.8	0.6	0.7	0.9
14	0.8	0.9	0.5	0.9	1.0
15	0.8	1.0	0.3	0.9	0.9
16	0.9	0.8	0.2	0.5	0.3
17	0.9	0.9	0.3	0.3	0.7
18	0.9	0.9	0.3	0.4	0.8
19	0.9	0.9	0.8	0.5	0.2
20	0.9	0.5	0.3	0.5	0.1

OBTAIN THE WEIGHTS AND MEAN SQUAREDEVIATION

Take the teaching indexes B1 as example, substitute these 20 groups of sample data in Eqs (1), (2) and (3), and solve the weight of teaching indexes α_1 and mean square deviation $\sigma_1 = 0.0104$. Then we get the evaluation indexes and their weights distribution in Teaching Indexes of the performance evaluation index system, as shown in TABLE 2 (weights rounded to two decimal places).

TABLE 2 : Distribution of teaching indexes

	Indexes	weights
Teaching indexes B1	Teaching workload B11	0.24
	Teaching attitude B12	0.15
	Teaching skills B13	0.23
	Teaching innovation B14	0.18
	Teaching resultsB15	0.22

Likewise we may solve the weights distribution of the other evaluation indexes, and finally solve the weights distribution of 5 primary indexes. Thus we solve all the weights distribution of this evaluation system and Figure out the final score of the teacher by integrating the score data.

RESULT AND DISSCUSS

It can be seen Based on the results of mean square deviation of each index, we obtain the index distribution with linear regression method as{0.24,0.15,0.23, 0.18,0.22}, close to those values the author obtains through fuzzy analytic hierarchy process w1={0.23,0.26,0.19, 0.13,0.19}[4]. Because the large sample data obtained through analytic hierarchy process are from experts and professors and the small real sample data obtained through regression analysis are from three levels——leadership, fellow teachers and students, the weights obtained from these two different sources are different.

CONCLUSIONS

As linear regression analysis stresses random sample selection and the index values and total score are based on real data, the solved weights distribution of the indexes in teachers' performance evaluation system is truthful (with minimum sample deviation) and therefore the evaluation results are scientific and rational with adequate theoretical basis.

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