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Research and Application of Graduate Satisfaction Based on SEM -- Take USTB as An Example

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Abstract. Based on the structural equation model and the characteristics of University Of Science and Technology Beijing(USTB), a graduate satisfaction evaluation model is constructed by using PLS estimation algorithm, and the fitting degree of the model is tested. It is found that the perceived quality has a great influence on the graduate satisfaction. It has a certain reference value for the improvement of school teaching and the application of structural equation model in the field of teaching.

Introduction

Structural equation model, also known as latent variable model, is the combination of factor analysis and path analysis [1]. It is an important statistical method for quantitative research in contemporary behavioral and social fields. It is an commonly used statistical modeling technology, which can introduce the latent variables to study the causal link between observed variables and find out the main factors which affecting teaching evaluation.

Chin [2] believes that the choice of two modeling methods depends mainly on the research purpose; Joreskog & Word [3] believes that when the purpose of the research is theoretical test and the theoretical knowledge is sufficient, LISREL should be used. From a theoretical point of view, China's college satisfaction model is mainly based on foreign models, and there is no mature and official framework. So the graduate satisfaction index model constructed in this paper is not yet mature, and the relationship between variables in the model needs to be verified in empirical research. Therefore, based on the above analysis, this paper should adopt PLS modeling technology.

Empirical Research on Graduate Satisfaction Model

Graduate Satisfaction Assessment Model Framework Setting

In order to understand the satisfaction of the USTB undergraduate students, from the perspective of students to find out the problems that the school may have in related work, the Academic Affairs Office conducted a questionnaire survey on the USTB 2018 Senior. This article constructed its index system according to the items involved in the questionnaire.

The survey in this study used the 5-point Likert scale. The higher the score, the higher the satisfaction. The scale including 3 main indicators: Teaching perception, Service perception and Student satisfaction.

Reliability and Validity Analysis

In May 2018, the Academic Affairs Office conducted a questionnaire survey of USTB 2018 seniors, distributed 3,249 questionnaires and collected 2,841 questionnaires. After the deletion of outliers and missing values, the total number of valid questionnaires was 2,650. The effective recovery rate of the questionnaire was 81.6%.

Table 1. 2018 USTB graduate satisfaction index system

Primary indicator	Primary indicator		Primary indicator
2018 USTB Graduate Satisfaction Index System	Perceived quality	Teaching perception	Teaching of professional teachers
			Teaching of teachers in public basic courses
			Teacher-student interaction
		Service perception	Teaching facilities
	Student satisfaction		Professional course satisfaction
			Public basic course satisfaction
			Internship satisfaction
			Overall satisfaction

Reliability. The internal consistency reliability analysis of the questionnaire was performed using SPSS22.0. The reliability coefficient of a scale with high reliability should be above 0.80. If it is between 0.70 and 0.80, it is acceptable. If it is a subscale, its reliability coefficient should be above 0.70, and if it is between 0.60 and 0.70, it can be used.

In this paper, the following results are obtained: Cronbach's Alpha of 3 latent variables are 0.870, 0.809, 0.758. All latent variables are considered credible and retained; the overall Cronbach's Alpha is 0.884, indicating that this data has a high internal consistency.

Validity. The method adopted in this study is: firstly, construct the theoretical model, and evaluate the structural validity of the scale by the model fitting of the confirmatory factor analysis, that is to say, the validity test of data is transformed into the evaluation of model fitting index in the evaluation of structural equation model, and the result will be reflected in the follow-up.

Structural Equation Analysis of Graduate Satisfaction Model

Mathematical Structure of the Model. Among the three latent variables, teaching perception and service perception are exogenous latent variables, expressed by ξ_1, ξ_2, and graduate satisfaction is endogenous latent variable. expressed by η.

The structural model between the latent variables is represented by a matrix:

$$\eta=\begin{pmatrix}\gamma_1 & 0\\ 0 & \gamma_2\end{pmatrix}\begin{pmatrix}\xi_1\\ \xi_2\end{pmatrix}+\zeta\ . \tag{1}$$

Where γ represents the path coefficient between the exogenous latent variable and the endogenous latent variable, and ζ represents the residual of the endogenous latent variable.

The measurement model between the exogenous latent variable and the observed variable is represented by a matrix:

$$\begin{pmatrix}x_1\\ x_2\\ x_3\\ x_4\\ x_5\\ x_6\\ x_7\\ x_8\\ x_9\\ x_{10}\\ x_{11}\\ x_{12}\end{pmatrix}=\begin{pmatrix}\lambda_1 & 0\\ \lambda_2 & 0\\ \lambda_3 & 0\\ \lambda_4 & 0\\ \lambda_5 & 0\\ \lambda_6 & 0\\ \lambda_7 & 0\\ 0 & \lambda_8\\ 0 & \lambda_9\\ 0 & \lambda_{10}\\ 0 & \lambda_{11}\\ 0 & \lambda_{12}\end{pmatrix}\begin{pmatrix}\xi_1\\ \xi_2\end{pmatrix}+\begin{pmatrix}\delta_1\\ \delta_2\\ \delta_3\\ \delta_4\\ \delta_5\\ \delta_6\\ \delta_7\\ \delta_8\\ \delta_9\\ \delta_{10}\\ \delta_{11}\\ \delta_{12}\end{pmatrix}. \tag{2}$$

Where λ represents the load factor of the observed variable on the exogenous latent variable and δ represents the residual of the exogenous variable.

The measurement model between the endogenous latent variable and the observed variable is represented by a matrix:

$$\begin{pmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \end{pmatrix} = \begin{pmatrix} \omega_1 \\ \omega_2 \\ \omega_3 \\ \omega_4 \end{pmatrix} \eta + \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \end{pmatrix}. \tag{3}$$

Where A represents the load factor of the observed variable on the endogenous latent variable, and B represents the residual of the exogenous variable.

After determining the mathematical form of the graduate satisfaction model, the parameters of the model can be estimated and tested.

Parameter Estimation of the Model. Firstly, standardization of explicit variables:

$$x_{ij} = (x_{ij1}, x_{ji2}, x_{ij3}, ..., x_{ijn}). \tag{4}$$

$$y_{ij} = (y_{ij1}, y_{ij2}, y_{ij3}, ..., y_{ijn}). \tag{5}$$

Make $E(x_{ij}) = E(y_{ij}) = 0$, i =1, 2, 3, …, 12, j =1, 2, 3, 4.

Secondly, Generating the external estimates of implicit variables:

$$X_i^{t+1} = f_i^{t+1} \sum_{j=1}^{k_1} (\omega_{ij}^t \cdot x_{ij}). \tag{6}$$

$$Y_i^{t+1} = g_i^{t+1} \sum_{j=1}^{k_2} (\omega_{ij}^{*t} \cdot y_{ij}). \tag{7}$$

Where X_i^{t+1} and Y_i^{t+1} are extrinsic estimate vectors after the t-th iteration of latent variables ξ_i and η_i. ω_{ij}^t and ω_{ij}^{*t} are the weight of the observed variable, f_i^{t+1} and g_i^{t+1} are the scalar quantity.

Thirdly, Generating intrinsic estimates of latent variables:

$$\xi_i^{t+1} = f_i^{*t+1} \sum_a (\theta_{ia}^{t+1} \cdot X_a^{t+1} + \lambda_{ia}^{t+1} \cdot Y_a^{t+1}). \tag{8}$$

$$\eta_i^{t+1} = g_i^{*t+1} \sum_a (\theta_{ia}^{*t+1} \cdot X_a^{t+1} + \lambda_{ia}^{*t+1} \cdot Y_a^{t+1}). \tag{9}$$

Where ξ_i^{t+1} and η_i^{t+1} are intrinsic estimate vectors after the t-th iteration of latent variables ξ_i and η_i. θ_{in}^{t+1}、θ_{in}^{*t+1}、λ_{in}^{t+1}、λ_{in}^{*t+1} are the weight of the observed variable.

Fourth, estimating weights.

$$x_{ij} = \omega_{ij}^{t+1} \xi_i^{t+1} + \varepsilon_{x,ij}^{t+1}. \tag{10}$$

$$y_{ij} = \omega_{ij}^{*t+1} \eta_i^{t+1} + \varepsilon_{y,ij}^{t+1}. \tag{11}$$

For the reflective model, the load becomes the weight of the explicit variable.

Fifth, calculate the vector corresponding to each latent variable using the iteratively determined weights:

$$\xi_i^T = \sum_{j=1}^{k_1} (\varpi_{ij}^T \cdot x_{ij}) . \tag{12}$$

$$\eta_i^T = \sum_{j=1}^{k_2} (\varpi_{ij}^{*T} \cdot y_{ij}) . \tag{13}$$

The superscript T represents the calculation result after the iteration.

Finally, using the value of the latent variable and the value of the explicit variable, the ordinary least squares regression is performed separately, and the load coefficient and the path coefficient are calculated. This article uesd SmartPLS 2.0 to calculated model parameters.

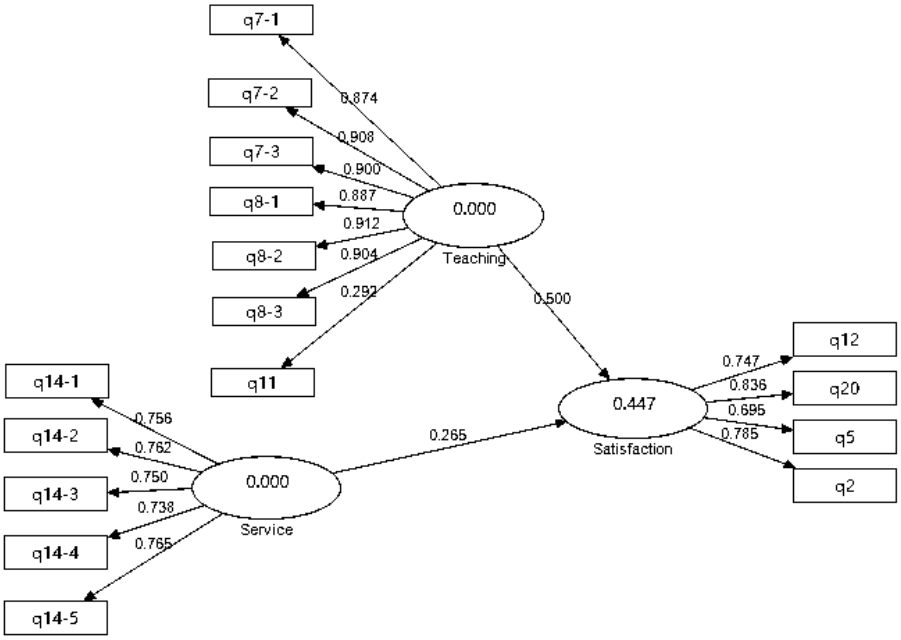

Figure 1. Graduate satisfaction index model road map

The output results showed the outer loadings and outer weights in each factor. The path coefficient between service perception, teaching perception and graduate satisfaction are 0.2648 and 0.5003, which are both ideal paths, and the teaching perception to satisfaction is more satisfactory to the service perception.

Outer loadings greater than 0.7 indicates that the observed variable responds well to the latent variable. The results show that the load coefficients of the other factors in the scale are greater than 0.7 except for the q5 and q11, and the average load coefficients of all the observed variables also reach 0.7819. Overall, the measurement effect of the observed variables is ideal.

In student satisfaction, the weights of the first three items are above 0.3, while the weights of the overall satisfaction degree are the highest, which is 0.3994. This shows that the satisfaction degree of professional courses, public courses and practice is less than that of the overall satisfaction degree

Model Inspection and Evaluation. PLS usually uses H^2 evaluation measurement model, R^2 evaluation structure model, and finally F^2 to evaluate the effect of the whole prediction relationship.

Table 2. Quality criteria of the model

	AVE	Composite Reliability	Cronbach's Alpha	R^2	H^2	F^2
Service	0.5688	0.8683	0.8111	0	0.5688	0
Teaching	0.7028	0.9394	0.9146	0	0.7028	0
Satisfaction	0.5889	0.8508	0.767	0.4467	0.5889	0.1143

In general, when AVE>0.5, Composite Reliability >0.7, Cronbach's Alpha>0.7, the model is satisfactory [4]. Table 2 shows that all three latent variables have passed the test of the above fitting index. This model shows good reliability and structural validity.

From the perspective of H^2, the commonality of the three latent variables is greater than 0.5, which indicates that all the latent variables have good predictive ability to their observed variables.

From the perspective of F^2, the overall predictive ability is general, because the R^2 of the graduate satisfaction is far below the standard value, resulting in the redundancy of only 0.1143. Although its H^2 is greater than the standard value, the overall fitting situation is still affected.

From the perspective of R^2, the R^2 value in the regression equation of graduate student satisfaction is only 0.4467, which is lower than the requirement of European Customer Satisfaction. We can guess that the graduate satisfaction is not only influenced by teaching and service, but by many other factors, such as the initial expectations of graduates, perceived values and the image of the school itself. Therefore, the model based on the Graduates Satisfaction in 2018 is incomplete. But we also know that perceived quality can explain nearly half of the changes in graduate satisfaction, which fully proves the importance of perceived quality in customer satisfaction model.

Summary

In this paper, the theory and application of structural equation model are studied. Based on the previous work and the characteristics of teaching evaluation, the structural equation model of graduate satisfaction and its index system are established. The adoption of structural equation model makes it more objective to confirm the weights of each factor in customer satisfaction model, and overcomes the subjectivity of using expert scoring directly in the existing factor-counting method.

However, the collected sample data of this study is only from Beijing University of Science and Technology, that means the result are unrepresentative; and the satisfaction of graduates and classroom teaching is an complicated system. It needs many levels of measurement. Due to the limitations of objective conditions, the model has fewer latent variables, which leads to less than ideal test results. The results of the graduate satisfaction model test show that the model does not explain the change in the satisfaction index sufficiently.

Acknowledgements

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