Assessing university library efficiency using Stochastic Frontier Analysis and analysis of the Influencing factors on University Library

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Abstract. University libraries provide forceful support for teaching and scientific research in universities, therefore the efficiency and its influencing factors of university libraries should be evaluated and analyzed, which is good for university libraries to play an important role in scientific communities. Firstly, the Stochastic Frontier Analysis method is used to evaluate the library efficiency of Shandong University of Business and Technology. The results show that the library efficiency shows an increasing trend from 1985 to 2019. Secondly, multiple regression econometrics model is used to analyze the factors affecting efficiency, and it is found that the number of students, the number of faculty, the purchase cost of electronic resources, the purchase cost of paper resources, the number of library staff, the number of hours of opening per week, the floor area, and the automation of business management are positively correlated with service efficiency. three Suggestions are put forward to enhance the service efficiency of library. (1) To realize the mutual match between the supply side and the demand side of library service; (2) Extend the opening hours of libraries to exchange time for space; (3) Carrying out the construction of intelligent library scientifically and rationally.

Keywords: university library; library efficiency; Stochastic Frontier Analysis ; influence factor

1   Introduction

University libraries are playing more and more important roles in teaching, scientific research and social service. With the continuous expansion of university scale, some university libraries continue to increase their investment in field area, the number of librarians, the number of books procurement, the scale of database procurement, information-based investment and so on. With the continuous investment of capital, manpower and technology, the service function of university library has been greatly improved. In the course of the development of university library, the efficiency of the service is not only a guide to the strategy of the construction of the library, but also a

guide to the efficiency of the service, moreover, it is the core issue for the library to realize the sustainable and healthy development.

In the 1940s, the University of Chicago published the Book Public Management and library, which marked the rise of the theory of library evaluation and efficiency evaluation[1].

The evaluation of library service efficiency can be divided into two types: qualitative and quantitative. Data Envelopment Analysis (DEA) is one of the earliest quantitative methods to evaluate the efficiency of a library. DEA is based on the Data of input and output, and is rarely disturbed by subjective Data Envelopment Analysis, therefore, it is widely used. Vitaliano used a Data envelopment analysis method to assess the efficiency of more than 190 libraries in New York[2]. The Data envelopment analysis uses linear programming methods to construct non-parametric piecewise surfaces (or fronts) of observed data, which is Deterministic system. In 1977,Aigner， Lovell and Schmidt proposed Stochastic Frontier Analysis(SFA) , which solved the problem by introducing a random variable representing statistical noise[3].In the literature of library efficiency, Stochastic Frontier Analysis is seldom used. This paper uses stochastic frontier analysis to evaluate the efficiency and analyze the influencing factors of Shandong Technology and Business University library, so as to provide measures and suggestions for the efficient operation of libraries.

2   Research Methodology

Aigner， Lovell and Schmidt proposed the following form of the stochastic frontier production function model[4]：

$$\ln q_i = x'\beta + v_i - \mu_i \tag{1}$$

Which q_i represents the i unit output;x_iRepresents a $K \times 1$ dimensional vector consisting of a logarithm of inputs;βrepresents the unknown parameter vector;$v_i$denotes statistical noise (statistical noise arising from both neglected x_i_related variables，also comes from the measurement error and the function form choice brings the approximate error);$\mu_i$represents a technical invalidity and is a non-negative random variable.

For the sake of convenience, it is important to consider the use of a unit that inputs $Ax_i$and produces q_i .In this case, the Cobb Douglas stochastic frontier model can be expressed as:

$$q_i = \exp\left(\beta_0 + \beta_1 \ln x_i\right) \times \exp\left(v_i\right) \times \exp\left(-\mu_i\right) \tag{2}$$

$\exp\left(\beta_0 + \beta_1 \ln x_i\right)$represents the determinate part of the output,$\exp\left(v_i\right)$ represents the part of the noise,$\exp\left(-\mu_i\right)$represents the technical invalidity of the output. The most commonly used output-oriented technical efficiency is the ratio of observable output to the corresponding stochastic frontier output:

$$TE_i = \frac{q_i}{\exp\left(x_i'\beta + v_i\right)} = \frac{\exp\left(x_i'\beta + v_i - \mu_i\right)}{\exp\left(x_i'\beta + v_i\right)} = \exp\left(-u_i\right) \tag{3}$$

The technical efficiency measure, which takes a value between 0 and 1, can measure the relative difference between the output of the i unit and that of the fully efficient unit using the same inputs.

3 Data Source

Shandong Technology and Business University Library was established in 1986 to provide strong support for teaching and research in schools. In order to be able to plan scientifically for the future development of libraries, an assessment of library efficiency over the past thirty-five years is needed. Following the well-known Cobb-Douglas production function, the library efficiency evaluation model only includes two inputs and one output. The two input factors are the new investment K (yuan，RMB) and the number of managers L (unit) .The output of the library can be measured by the total number of students and teachers served each year Q (unit) .

Choosing every five years as a research unit, a total of seven research units (i.e. 1985-1989,1990-1994,1995-1999,2000-2004,2005-2009,2010-2014,2015-2019). Taking the average input and output data of every five years to evaluate the efficiency can reduce the fluctuation of sample random error and reflect the changing trend of library efficiency. The basic data from 1985 to 2019 can be obtained by find and flip the working records of the Library of our university, financial records and personnel records .

4 Efficiency Analysis

According to the model (1) , we can write a stochastic frontier mathematical model of library efficiency evaluation:

$$\ln Q_i = \beta_0 + \beta_1 \ln K_i + \beta_2 \ln L_i + v_i - \mu_i \tag{4}$$

Using FRONTIER4.1 and assuming that the distribution of the influence factors of the unit follows the truncated normal distribution random variable, the data file, the command file and the output file are compiled, and the parameter estimation results are as follows:

$$\ln \hat{Q}_i = 0.13808 + 0.79033 \ln K_i + 0.45786 \ln L_i \tag{5}$$

$$（2.05692）\qquad （3.18380）\qquad （2.96092）$$

From the economic point of view of the parameters, the estimated values of the structure parameters are all between 0 and 1, which well explains the fact that the investment and the number of the managers are the main factors affecting the service efficiency of the library. The statistical test shows that the goodness-of-fit $R^2 = 0.9042$，sample point and curve fit are high. The t-test shows that the investment and the number of

managers have a significant impact on the library service efficiency. The results of the unit efficiency assessment are shown in Table 1.

Table 1. results of unit efficiency evaluation [Self-drawing]

unit	unit1	unit2	unit3	unit4	unit5	unit6	unit7
technical efficiency	0.64091	0.81878	0.91429	0.96068	0.98221	0.99201	0.99642

The result of efficiency evaluation shows that the average technical efficiency of our library is 0.64091 from 1985 to 1989, and 0.99642 from 2015 to 2019. The technical efficiency shows an overall increasing trend, it indicates that the management level and service function of our university library have been improved continuously.

5   Factor Analysis of Efficiency

5.1   Selection of Influencing Factors

This article is based on the reality of Shandong Technology and Business University Library, and considering the availability of data, Choose the main influence factors include the number of students in school of X_1 (people),the number of staff X_2 （people),staff average age X_3 （years), electronic resources purchase expense X_4 （yuan，RMB), paper resources purchase expense X_5 (wan yuan，RMB), library staff X_6 (people),the proportion of senior title of professional employees X_7 (%),opening hours, weeks by 8 (hours), X_8 （hours）、 construction area of X_9 （m^2）. In 2005, our school realized the full automation of library business management. In order to analyze the impact of automation on efficiency, In 2005, our school realized the full automation of library business management. In order to analyze the impact of automation on efficiency, This article introduces a virtual variable X_{10}，$X_{10} = 0$ before automation and $X_{10} = 1$ after automation.

5.2   Analysis of Influencing Factors

Taking the above factors as explanatory variables and the technical efficiency measured every year for 35 years as explanatory variables, the following regression models were established:

$$TE = \alpha_0 + \sum_{i=1}^{10} \alpha_i X_i + \mu_i \tag{6}$$

TE is the efficiency measure for each year,α_i （i = 0,1,···,10）is the parameter to be estimated,X_i （i = 1,2,···,10）represents each of the 10 explanatory variables,μ_i is a random error term. At the significant level $\alpha = 0.1$,the average age of employees is not significant to the explained variable, so it needs to be eliminated. According to the model (6) , the model regression results of the factors affecting library efficiency can be obtained, as shown in Table 2.

Table 2. Results of model parameter estimation excluding non-significant variables[Self-drawing]

Variable	Coefficient	Standard error	T statistic quantity	P value
X_1	0.65627	0.34458	1.90452	0.065
X_2	0.14321	-0.06804	-2.10461	0.003
X_4	0.11595	0.03862	3.00190	0.070
X_5	0.02589	0.01292	2.00415	0.025
X_6	0.05659	-0.01653	-3.42430	0.070
X_7	-0.25124	-0.12686	1.98045	0.015
X_8	0.24671	0.12639	1.95197	0.001
X_9	0.21597	-0.09422	-2.29219	0.035
X_{10}	0.32489	0.11892	2.73206	0.001

The goodness of fit of the model is $\overline{R}^2 = 0.85214$,and the model fits well.When the significance level $\alpha = 0.1$, the t statistic value is larger than the standard value, which indicates that the explanatory variable has a significant effect on the efficiency. Therefore, the model can be considered as an ideal regression model.

The number of students and teaching staff is the main service object of the library. If the number of students and teaching staff is large, the service efficiency of the library has potential room for improvement. Since the expansion of our school, the efficiency of the library has also been greatly improved. The higher the proportion of senior title staff, the lower the service efficiency. The higher the proportion of senior title staff, the lower the service efficiency is. The reason is that the staff with high professional title can get high salary, the library will invest more money in manpower, and the staff with high professional title and the staff with middle professional title have the same work nature and intensity. The number of opening hours in a week has a positive effect on the efficiency, second only to the number of students in school, and the extension of opening hours can meet the needs of more readers. Library building area is also an important factor. Generally speaking, the larger the area of a library, the more opportunities readers have to receive services, and the more efficient the library will be. However, the building area of a Library should also match the scale of running a school, otherwise it becomes a constraint on efficiency. The purchase of electronic resources and the purchase of paper resources can promote the efficiency of library services, compared with the purchase of paper resources, the increase of the purchase of electronic resources can promote the efficiency. The virtual variable is remarkable, which shows that the full-scale automation of library business management has played an important role in improving the efficiency.

6   Conclusion

This paper evaluates the efficiency of Shandong Institute of Business and Technology Libraries by using the stochastic frontier efficiency analysis method, and discusses the influencing factors of library efficiency, it is hoped that this paper can provide some reference for the future five-year development plan of our University Library. Through the analysis of the statistical results, this paper holds that the number of students in school and office automation are the two most important factors that affect

the efficiency, the user is the service object of the university library, is in the work center of the University Library, only the user to our service approval and satisfaction, our service is the real effective service [5], we should strive for the matching of the supply side and the demand side of the library service, take the demand side as the guidance, actively promote the supply side reform, extend the opening time of the library can effectively improve the service efficiency of the library,using high-tech means such as Internet of things and cloud computing, intelligent library has obvious advantages in information processing, knowledge service and individual experience[6], the Intelligent Library is an important model for the efficient operation of the library.

7   References

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