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Research on the Technical Efficiency and Influencing Factors of Information Service Industry in China

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Abstract

Information service industry can effectively promote the industrial technological progress. And it is one of the key industries of all countries in the world. In this paper, we study the technical efficiency and influencing factors of China's information service industry in a stochastic frontier production function over the period of 2010-2014. Our results show that the overall level of technical efficiency of information service industry in China is constantly improving, there is a big difference between the technical efficiency of Chinese regions, and the technical efficiency of information service industry in China is influenced by factors such as education level. Finally, policy implications are drawn from our results.

Keywords

Information Service Industry, Technical Efficiency, Translog Production Function, Industry Analysis

1. Introduction

In recent years, the rapid development of information technology promotes the progress of productivity. Many countries in the world have developed information strategy to promote the development of information industry. With the development of information industry, information technology has penetrated into various industrial categories to speed up the development of the economy around the world. As an important part of the information industry, information service industry has become an important way to form a new industrial structure in developing countries. China is fully aware of the important role of information service industry in the transformation of development mode and the optimization of the industrial structure, and actively promotes the development of information service industry. Information service industry has become an important area of the integration of informatization and industrialization in China.

At present, the research on information service industry in China is mainly about the qualitative research on the development of information service industry in China, and the quantitative research is not a lot. Xu Huan and Hou Dayi (2005) put forward a two-stage strategic development model for China's information service industry on the basis of the information service industry development mode in developed countries. Yang Yi (2006) analyzed the development experience of information service industry in the United States, and she suggested that China should learn from the United States to take measures such as the construction of legal system to promote the development of information services. Yang Xiangming (2007) discussed the development of China's information service industry from the perspective of application practice, development direction and development strategy. Xu Limei (2008) analyzed the status quo of the development of information service industry in China, discussed the future development trend and put forward some strategies. Chen Jianlong and Wang Jiandong (2009) compared the different strategic development patterns of information service industry in China, and found that the policy of China's local governments is different from each other. Li Chao (2011) evaluated the development level of information service industry in 31 provinces of China, discussed the difference of development level between different provinces, and analyzed the advantages and disadvantages of the development of information service industry in each province. Ji Yahui and Yang Yingde (2012) studied the influencing factors for 191 cities of China over the period of 2005-2010, using theory and methods from spatial statistics and spatial econometric. The results shows that the urban informatization level and the human capital has a significant positive effect on the development of information service industry, and the effect of the level of opening to the outside is not obvious. Zhou Zhidang (2012) analyzed the integration mechanism between information service industry and manufacturing industry, and put forward some policy recommendations for promoting the integration of information service industry and manufacturing industry. Guo Ren (2013) defined the concept of service capability of information service industry, and analyzed many factors which affected the service capacity of information service industry. Cheng Huiping (2013) used data envelopment analysis (DEA) and stochastic frontier analysis (SFA) to compare and analyse the technical efficiency of the information service industry of the 30 provinces of China over the period of 2001-2010. The results show that the mean efficiency measured by DEA and SFA are remarkable different, but have a high correlation up to 68.3%, and the value of technical efficiency and the performance of information service industry are significantly positive correlation. Yao Wei and Liu Jianzhun(2014) proposed a virtual spiral model for information service industry to provide effective service for customer needs, and they thought that the key to providing effective information services was to carry out the customer oriented service. Lin Changhua (2014) analyzed the development of information service industry in China from the perspective of input-output, and evaluated the efficiency of information service industry based on the method of data envelopment analysis. The research shows that the overall development efficiency of information service industry in provinces of China is obviously different from each other, and the information service industry in China has formed four kinds of classification modes according to the different efficiency. Yao Wei and Liu Jianzhun proposed a new management philosophy of modern information service industry to provide effective service for customer needs, and they constructed a virtual spiral model of "information-interaction-transaction-configuration". Yin Xiaoqian et al. (2015) analyzed the supporting role of information service industry in manufacturing and value chain from the perspective of the integration of informatization and industrialization, and discussed the strategies for information service industry to support the development of manufacturing industry. This paper uses SFA to calculate the technical efficiency of information service industry in China for panel data, and analyzes the effect of human resources and other influencing factors on the technical efficiency of information service industry in China.

2. Research Design

2.1 Research Model

The stochastic frontier production function was independently proposed by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977). The original specification involved a production function specified for cross-sectional data which had an error term which had two components, one to account for random effects and another to account for technical inefficiency. This model can be expressed in the following form:

$$Y_i = X_i\beta + (V_i - U_i), i = 1,\dots, N \quad (1)$$

where Y_i is the production of the i-th firm;

X_i is a vector of input quantities of the i-th firm;

β is a vector of unknown parameters;

the V_i are random variables which are assumed to be iid. $N\left(0,\sigma_v^2\right)$, and independent of the U_i which are non-negative random variables which are assumed to account for technical inefficiency in production and are often assumed to be iid. $\left|N\left(0,\sigma_U^2\right)\right|$.

This original specification has been used in a vast number of empirical applications over the past decades. The specification has also been altered and extended in a number of ways. Battese and Coelli (1992) proposed a stochastic frontier production function for (unbalanced) panel data which has firm effects which are assumed to be distributed as truncated normal random variables, which are also permitted to vary systematically with time. The model can be expressed as:

$$Y_{it} = x_{it}\beta + (V_{it} - U_{it}) \ , i = 1, \ldots, N \quad , t = 1, \ldots, T \qquad (2)$$

Where Y_{it} is (the logarithm of) the production of the i-th firm in the t-th time period;

x_{it} is a $k \times 1$ vector of (transformations of the)input quantities of the i-th firm in the t-th time period;

β is as defined earlier;

the V_{it} are random variables which are assumed to be iid. $N\left(0, \sigma_v^2\right)$, and independent of the $U_{it} = (U_i \exp(-\eta(t-T)))$,where

the U_i are non-negative random variables which are assumed to account for technical inefficiency in production and are assumed to be iid as truncations at zero of the $N\ (\mu, \sigma^2)$ distribution;

η is a parameter to be estimated;

and the panel of data need not to be complete(i.e. unbalanced panel data).

This model is such that the non-negative firm effects, U_{it}, decrease, remain constant or increase as ti increases, if $\eta > 0, \eta = 0$ or $\eta < 0$, respectively. The case in which η is positive is likely to be appropriate when firms tend to improve their level of technical efficiency over time. The method of maximum likelihood is proposed for simultaneous estimation for the stochastic frontier model. The likelihood function is expressed in terms of the variance parameter, $\sigma_s^2 \equiv \sigma_v^2 + \sigma^2$ and $\gamma \equiv \sigma^2 / \sigma_s^2$. The variance parameter must lie between 0 and 1.

Battese and Coelli (1995) proposed another model for technical inefficiency effects in a stochastic frontier production function for panel data. This model not only can analyze the technical efficiency of each decision making unit, but also can analyze the technical inefficiency effects. The model may be expressed as:

$$Y_{it} = x_{it}\beta + (V_{it} - U_{it}) \ , i = 1, \ldots, N \quad , t = 1, \ldots, T \qquad (3)$$

where Y_{it} , x_{it} , β are as defined earlier;

the V_{it} are random variables which are assumed to be iid. $N\left(0, \sigma_v^2\right)$, and independent of the

U_{it} which are non-negative random variables which are assumed to account for technical inefficiency in production and are assumed to be independently distributed as truncations at zero of the $N\ (m_{it}, \sigma^2)$ distribution; where:

$$m_{it} = z_{it}\delta \quad (4)$$

where z_{it} is a vector variables which may influence the efficiency of a firm, and δ is a vector of parameters to be estimated.

The inefficiency effects, U_{it} , in the stochastic frontier model (3) could be specified in equation (5),

$$U_{it} = z_{it}\delta + W_{it} \quad (5)$$

where the random variable, W_{it}, is defined by the truncation of the normal distribution with zero mean and variance, σ^2, such that the point of truncation is $-z_{it}\delta$, i.e., $W_{it} \geq -z_{it}\delta$.

The technical efficiency of production for the i-th firm at the t-th observation is defined by equation(6),

$$TE_{it} = \exp(-U_{it}) = \exp(-z_{it} - W_{it}) \quad (6)$$

According to the model of Battese and Coelli (1995), this paper uses Translog production function to measure the technical efficiency of the information service industry in China. The stochastic frontier production function to be estimated is

$$\ln Y_{it} = \beta_0 + \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \beta_3 t + \beta_4 (\ln K_{it})^2 + \beta_5 \ln K_{it} \ln L_{it} + \beta_6 t \ln K_{it} + \beta_7 (\ln L_{it})^2 + \beta_8 t \ln L_{it} + \beta_9 t^2 + V_{it} - U_{it} \quad (7)$$

where the technical inefficiency effects are assumed to be defined by

$$U_{it} = \delta_0 + \delta_1 t + \delta_2 (Education_{it}) + \delta_3 (Goverenment_{it}) + W_{it} \quad (8)$$

where Y is the output of the information service industry for the provinces in China;

L is the capital investment of the information service industry;

K is the labour input of the information service industry;

t indicates the time period of the observation involved;

Education represents the education level of labour force;

Government refers to the government influence; and

V_{it} and U_{it} are as defined in the previous section.

2.2 Data Sources and Variable Description

There is no universally accepted conclusion on the scope of information service industry in the world. And there are still some differences in the connotation and extension of the information service industry in the world. In the national economy new industry classification standard

(GB/T4754-2001) of China national bureau of statistics, the information service industry mainly refers to the information transmission, software and information technology services industry. The information services industry has three major categories of content. They are the telecommunications, radio, television and satellite transmission services, Internet and related services, software and information technology services. In this paper, after considering the availability of data and the consistency of statistical calibre, we adopt the classification criteria. The data used in this paper comes from < China Statistical Yearbook > (2011-2015), the statistical yearbook (2011-2015) of the provinces in China and the website of China National Bureau of statistics.

The output variable of information service industry is represented by the value-added of the information service industry of each province in China. In order to eliminate the impact of price factor, the value-added of the information services industry each year is deflated by industrial price index (with 2010 as the base period). The labour variable of the information service industry is indicated by number of employed persons at year-end of each province. The capital variable of the information service industry is represented by gross fixed assets of the information service industry of each province, and the value of gross fixed assets is adjusted by the price index of investment in fixed assets.

The development of information service industry needs a large number of educated workforces. So the education level of labor force is an important factor which can affect the technical efficiency of the information service industry. In technical inefficiency function, the educational level of labor force is indicated by number of regular students enrolled in normal and short-cycle course in regular higher education. The government's attention to the development of information service industry will affect the development of local information service industry. The government's attention to the information service industry will affect the development of local information service industry, thus the government's influence is also a factor that needs to be considered. The measure of the government influence is difficult, and we use percentage of government public finance expenditure to GDP to indicate government influence. In order to reflect the time varying characteristics of the technical efficiency of information service industry, time factor is brought into the technical inefficiency function.

3. Results and discussion

3.1 Estimation results

Maximum-likelihood estimates of the parameters of the model (7)-(8) are obtained using the computer program, Frontier4.1. Those estimates are shown in table 1.

The estimate for the variance parameter, γ, is one, which indicates that the inefficiency are highly significant in the analysis of the value of output of the information service industry. Generalized likelihood-ration tests of null hypotheses, that the inefficiency effects are absent or that they have simpler distributions, are presented in Table 2. The first null hypothesis, which specifies that stochastic frontier production function uses the form of Cobb-Douglas production function, is strongly rejected. The second hypothesis, which specifies that there is no technical change, is strongly rejected. The third hypothesis, which specifies that the inefficiency effects are absent from the model, is also strongly rejected. The above discussion shows that the stochastic frontier function which is set by this paper is reasonable.

Table 1. Maximum-likelihood Estimates for Parameters of Stochastic Frontier Production Function

Variable	Parameter	Coefficient estimate	T-statistic
Constant	β_0	6.574***	18.102
$\ln K_{it}$	β_1	-0.184	-0.702
$\ln L_{it}$	β_2	0.519***	2.791
t	β_3	-0.763***	-5.193
$(\ln K_{it})^2$	β_4	-0.175***	-3.785
$\ln K_{it} \ln L_{it}$	β_5	0.235**	2.562
$t \ln K_{it}$	β_6	0.083**	2.475
$(\ln L_{it})^2$	β_7	-0.044	-1.070
$t\ln L_{it}$	β_8	-0.106***	-2.992
t^2	β_9	0.139***	9.380
Constant	δ_0	1.519***	9.278
t	δ_1	-0.088**	-2.025
$Education_{it}$	δ_2	-0.438E-06***	-5.114
$Goverment_{it}$	δ_3	0.287	1.100
	σ^2	0.070***	7.154
	γ	1.000***	106.394
	Log(likelihood)	-11.586	

*** Significant at the 1 percent level of significance.

** Significant at the 5 percent level of significance.

* Significant at the 10 percent level of significance.

The estimated coefficient for the labour variable, 0.519, is highly significant, while that for the capital variable is not significant. The positive elasticity for the labour variable means that the labour input of information service industry plays a positive role in the development of the information service industry in China. The negative elasticity for the capital variable indicates that the effect of capital investment in information service industry is gradually decreasing. The information service industry in China is gradually transforming from capital intensive to intelligence intensive, and the role of human resources is becoming more and more prominent.

Table 2. Tests of hypotheses for parameters of the inefficiency frontier model

Null Hypothesis	Log(likelihood)	$\chi^2_{0.01}$-value	Test statistic
$H_0=\beta_3=\beta_4=\beta_5=\beta_6=\beta_7=\beta_8=\beta_9=0$	-65.452	18.475	107.732***
$H_0=\beta_3=\beta_6=\beta_8=\beta_9=0$	-59.598	13.277	96.024***
$H_0=\gamma=\delta_0=\delta_1=\delta_2=\delta_3=0$	-32.829	15.086	42.486***

*** Significant at the 1 percent level of significance.

3.2 Discussion

In the technical inefficiency function, the negative coefficient for t indicates that the inefficiencies of production of the information service industry tend to decline throughout the five-year period. The education coefficient is negative, which shows that the education level of human resources has a positive impact on the efficiency of the information service industry. Higher education level will make the efficiency of the local information service industry improved. Ji Yahui and Yang Yingde (2012) had the same conclusion in their paper. The positive estimate for government suggests that government influence on the efficiency of the information service industry has a negative effect. Excessive government intervention will reduce the efficiency of information service industry. This result is very consistent with China's actual situation. Some of the industries in China have not developed well because of excessive government interference, and some industries with little government interference have developed very well. The Chinese government should pay attention to their role in the development of the industry, and strive to make the market play a leading role.

The technical efficiency of the information service industry for Chinese provinces across the years is presented in Table 3. A higher score in Table 3 indicates a higher technical efficiency for that province in a given year. The technical efficiency of China's information service industry has gradually increased, from 0.353 in 2010 to 0.454 in 2014. The results imply that the technical efficiency of individual province changes with time, and we believe there is still tremendous room for technical efficiency to improve. From the point of view of the spatial distribution of technical efficiency, there is a big difference among eastern China, central China and western China. The technical efficiency of eastern China is the highest, and the average technical efficiency is 0.460. The technical efficiency of central China is located at second, and the average technical efficiency is 0.397. The technical efficiency of western China is the lowest, and the average technical efficiency is 0.349. Li Chao (2011) had similar conclusions in his studies. But he used the cross section data in his paper, and the panel data was used in this paper. From the point of view of the time variation of technical efficiency, the technical efficiency varies up and down over time. The change of technical efficiency in the eastern and central regions of China is in the form of wave, first decreased, then increased and then decreased. The technical efficiency of the western China has been on the rise after the initial decline. The difference of technical efficiency between provinces in China is relatively large. The average technical efficiency of Guangdong is the highest, and the highest in the year its technical efficiency is 0.998. Tibet's average technical efficiency is only 0.201 and ranking is located in the end of the technical efficiency of all provinces in China. The gap between the two is known to reach 0.564. Technical efficiency in the same region is not balanced. The technical efficiency of Guangdong in the eastern China is high, but the technical efficiency of Tianjin in the eastern China is relatively low in the whole country.

Table 3. Technical Efficiency of provinces in China

Province	2010	2011	2012	2013	2014	Avg.
Beijing	0.261	0.264	0.296	0.323	0.300	0.289
Tianjing	0.257	0.208	0.246	0.308	0.308	0.265
Hebei	0.607	0.349	0.525	0.588	0.560	0.526
Shanghai	0.358	0.312	0.411	0.420	0.399	0.380
Inner Mongolia	0.257	0.190	0.298	0.315	0.356	0.283
Liaoning	0.279	0.241	0.351	0.390	0.327	0.318
Jilin	0.260	0.203	0.284	0.302	0.266	0.263
Heilongjiang	0.276	0.193	0.277	0.331	0.314	0.278
Shanghai	0.342	0.320	0.456	0.470	0.410	0.400
Jiangsu	0.481	0.383	0.574	0.473	0.468	0.476
Zhejiang	0.417	0.364	0.637	0.779	0.750	0.589
Anhui	0.339	0.296	0.458	0.520	0.470	0.417
Fujian	0.354	0.310	0.527	0.657	0.659	0.501

Jiangxi	0.307	0.276	0.373	0.415	0.350	0.344
Shangdong	0.733	0.493	0.677	0.671	0.552	0.625
Henan	0.590	0.550	0.718	0.713	0.652	0.645
Hubei	0.385	0.279	0.465	0.498	0.461	0.418
Hunan	0.308	0.277	0.466	0.552	0.551	0.431
Guangdong	0.625	0.516	0.789	0.998	0.898	0.765
Guangxi	0.326	0.234	0.391	0.475	0.550	0.395
Hainan	0.313	0.206	0.352	0.378	0.295	0.309
Chongqing	0.266	0.216	0.324	0.415	0.426	0.330
Sichuan	0.404	0.376	0.678	0.556	0.547	0.512
Guizhou	0.279	0.309	0.605	0.625	0.482	0.460
Yunnan	0.364	0.281	0.425	0.448	0.542	0.412
Tibet	0.152	0.169	0.298	0.193	0.192	0.201
Shaanxi	0.270	0.226	0.316	0.394	0.336	0.308
Gansu	0.341	0.245	0.368	0.387	0.411	0.350
Qinghai	0.221	0.208	0.203	0.204	0.245	0.216
Ningxia	0.208	0.184	0.286	0.308	0.442	0.285
Xinjiang	0.378	0.257	0.424	0.535	0.566	0.432
Eastern China	0.424	0.332	0.494	0.549	0.502	0.460
Central China	0.353	0.298	0.431	0.469	0.433	0.397
Western China	0.289	0.241	0.385	0.404	0.425	0.349
China	0.353	0.288	0.435	0.472	0.454	0.401

4. Conclusion

In this paper, we use the method of stochastic frontier analysis to measure the technical efficiency of information service industry in China over the years of 2010 through 2014. The impact of human resources education level, government influence and other influencing factors on the technical efficiency of information service industry has also been discussed. The results obtained in this paper show that the technical efficiency of information service industry in China is rising with the time, and the technical efficiency has a larger space for development. The human resources education level has a positive effect on the technical efficiency of information service industry, and the effect of the government influence on the technical efficiency of information service industry is negative.

Information service industry is an important part of the economic and social development in various countries and regions in the world. It is an important driving force for the adjustment of regional industrial structure. We suggest that China should increase investment in education to raise the level of education for all people. China should also pay attention to the training of employees, so that the overall quality of employees can continue to improve. Through the above methods, the development of China's information service industry will be able to obtain the necessary well educated personnel. The role of the government in the development of information service industry should be seriously considered. China should avoid excessive intervention to provide a good market environment for the development of information service industry. Following the rules of industrial development, the government provides the necessary help and not interferes, so that the development of the information service industry can be better.

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