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An Empirical Research on Technological Efficiency & Its Influential Factors of Low Carbon Enterprises in China

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Abstract

Based on the public listed firms' panel data (from 2003 to 2009), this study uses the stochastic frontier models of the Cobb-Douglas to analyze the technological efficiency (TE) and its influential factors of low carbon enterprises in China. The research reveals that the average TE is 0.751 of low carbon enterprises in China, and the TE varies among enterprises. There is room for the firms to improve their TE. Instead of labor, it is the capitals that mainly attribute to the development of TE, and the fund utilizing capacity also has a significant influence on the TE of low carbon enterprises in China, however, technical capacity and the scale of the enterprises have a negative effect on the TE. The capital structure, to some extent, restrains the increase of TE. The TE of low carbon enterprises increases year annually, but the tendency is not apparent.

Key words: Low carbon enterprises; Stochastic frontier analysis; Indigenous technical efficiency

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INTRODUCTION

Nowadays, people pay increasing attention to low carbon economy because of concerns on global warming and the safety of energy. It is England who first pointed out the low carbon economy. The essence of the economy is the efficiency of the energy and the structure of clean energy, and the core of it is the technical innovation of energy and the innovation of institution. The purpose of this economy is to alleviate the trend of climate change, and to keep sustainable development. The social economy and environment both have influence on the development of the economy in China. Currently, the output of carbon dioxide has a significant effect on the environment. From December the 7th to 18th in 2009, the conference with the thyme of "The Last Chance to Rescue the Human" of Copenhagen, UN Climate Change Conference was held in Norway. China pointed out that the output of carbon dioxide of China will decrease 40% to 45% till 2020, and the output of carbon dioxide have been considered as a confinement to the mid-term and long term development of social economy and development. Thus, the development of low carbon economy still needs a long and hard way to go. Recently, the low carbon economy has become a hot topic among researchers.

There are some researches concerning low carbon economy abroad, such as Johnston (2005), Kawase (2006), Shimada (2007) etc, but only a few relative researches in China, such as Feng Zhijun (2009), Xia Ning (2009), Chen Xiaochun (2009), Cai Meng (2010), Huang Dong (2010), etc. The researches in China mainly analyze the strategy and policy of the low carbon economy, using qualitative but quantitative methods. Song Bangying (2010) analyzed the relationship between the output of carbon dioxide and low carbon economy using GWR. Zhou Yuanchun concentrated on how the structure of energy efficiency of energy, and development of economy influenced the development of low carbon economy using an empirical research. However, there is little about the

quality of low carbon economy from the standpoint of the enterprises, even though it is important to the development of low carbon economy in China.

This study focuses on the quality of low carbon enterprises from the perspective of technology. It adopted the public listed firms' data of 37 enterprises using the stochastic frontier model of Cobb- Douglas production function to analyze the main influential factors of developmental pattern and the increase of the low carbon economy in China.

1. CONSTRUCTION OF THE MODEL AND SELECTION OF THE DATA

1.1 The Construction of the Model

There are two methods to measure the TE in empirical analysis, one is DEA, and the other one is SFA, which is adopted by this article. The reason to choose the SFA is that it can not only construct independently stochastic model, but also can measure the parameter in the model and the adaption of the model. Thus, SFA has the ability to make the data closer to the reality. On the other aspect, DEA ignores how the stochastic error influences the output of low carbon enterprises, and doesn't take the price-which has a significant influence on efficiency, into consideration. Thus, based on the same data, SFA will obtain much more exact result than DEA (Gong and Sickles, 1992).

This article builds the stochastic frontier production function model according to the theory of Battese & Coelli.

(1)

(2)

$$\ln(y_{it}) = \beta_0 + \beta_1 \ln(K_{it}) + \beta_2 \ln(L_{it}) + v_{it} - u_{it} \quad (3)$$

$$m_{it} = \delta_0 + \delta_1 (ZJYYNL)_{it} + \delta_2 (JJNL)_{it} + \delta_3 (SCALE)_{it} + \delta_4 (ZBJG)_{it} + \delta_5 t + W_{it} \quad (4)$$

$TE_{it} = \exp(-u_{it})$ er of the low carbon enterprises, i=1,2,3 …, N, N=37;t represents the serial number ,$\gamma = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2)$=7 (start from 2003); y_{it} Represents the output of i enterprise in t year; I_{it} Represents the labor input of i enterprise in t year; k_{it} Represents the capital input of i enterprise in t year; β_0 Is the intercept; β_1, β_2 are stay estimated parameter; β_1 = capital output elasticity, represents the influential degree of capital to TE; β_2 = labor output elasticity, represents the influential degree of labor to TE; ε_{it} = error term, including two components: the first part is $V_{it} \in$ iid, and $V_{it} \sim N(0, \sigma_V^2)$, it represents the external influential factors and statistic error; the second part is $u_{it} \in$ iid, and $u_{it} \sim N(m_{it}, \sigma_V^2)$, it reflects the random factors of i province's in t year; e^{-mit} reflects the technical efficiency level of i enterprise in t year; m_{it} is the term of technical inefficiency, the bigger the m_{it} is, the lower the technical efficiency is; v_{it} and u_{it} are dependent from each other.

This study mainly focuses on how the fund utilizing capacity, technical capacity, enterprises' structure, and time influence the indigenous technical inefficiency of low carbon enterprises.

In equation (2), σ_0 is the stay estimated constant, $\sigma_1 \sim \sigma_5$ separately represent the influence of fund utilizing capacity, technical capacity, enterprises' scale, capital structure, and time. W_{it} is the stochastic error of technology invalid equation , and $W_{it} \sim N(0, \sigma_W^2)$.

In equation (3), $ET = \exp(-u_{it})$ means technology capability of i enterprise in t year. $u_{it} = 0$, $ET_{it} = 1$ means indicates that the enterprise is in the state of effectiveness, at this moment ,the deployment point is in production frontier surface; $u_{it} > 0$, $0 \leq ET_{it} \leq 1$ indicates the enterprise is in the state of ineffectiveness, and the production is beneath the production frontier.

In equation (4), $\gamma = 0.951$ is the stay estimated parameter it represents the ratio of technology inefficiency among stochastic interference terms. When r is close to 1, it means the error of the model mainly comes from technical inefficiency u_{it} —the distance between the actual output and the frontier production mainly comes from loss caused by technical inefficiency; When r is close to 0, it indicates that actual production is as the same as the frontier production, at this moment OLS is suitable.

1.2 Selection of Data Resource

The sample period of this article is from 2003 to 2009. According to CSRC (China Security Regulatory Commission), there are 58 low car bon listed-firms, the article selects 37 of them, and neglect those who has data and negative increase of output. The data of the sample all come from the listed-firms' annual report from 2003 to 2009.

The Variables are as follows:(1) y_{it} = the ncrease of output in i enterprise t year(operating earnings + total wages,unit:10 thousand). I_{it} = the number of the employees in i enterprise t year (unity: member), k_{it} = the total assets of i enterprise t year (unity: 10 thousand). (2) $(ZJYYNL)_{it}$ = the fund utilizing capacity, it represents the circulating rate of total assets of i enterprise t year. It is used to reflect the influence of the capital utilizing capacity to the technical inefficiency); $(JJNL)_{it}$ = technical capacity, it is the ratio of technician of i enterprise in t year. It is used to measure the technical capacity's influence to the technical inefficiency of low carbon enterprises. $(SCLE)_{it}$ = the enterprise' scale of i enterprise in t year. It reflects how the scale influences the technical inefficiency of low carbon enterprises. $(SCALE)_{it}$ is a dummy variable. This article adopts the average of total assets as critical point. When the enterprise' total assets< the critical point, $(SCALE)_{it} = 1$ otherwise $(SCALE)_{it} =$

0; $(ZBJG)_{it}$ = the structure of the capital, it means the assets liability ratio of i enterprise in t year. It shows how the structure influences the technical inefficiency of low carbon enterprises. T represents the time, and it is used to reflect the change of the technical inefficiency.

2. THE EMPIRICAL RESULT AND THE ANALYSIS

According to above research and panel data, the article adopts Frontier 4.1 software to estimate the technical efficiency and its influential factors of low carbon enterprises in China from 2003 to 2009.

The result are as follows: r= 0.0951 close to 1,and the LR is apparent .It means the inaccuracy term of the method has apparently complex structure, and the error mainly come from technical inefficiency. Thus, it is necessary to use stochastic frontier production function to analyze the panel data of low carbon enterprises. From the standpoint of the estimated result ,the method is acceptable and reasonable.

Table 1
The TE of Low Carbon Enterprises in China

Name of the firm	2003	2004	2005	2006	2007	2008	2009	average
Southern Glass A	0.824	0.869	0.719	0.474	0.843	0.696	0.593	0.717
Zhong Cheng manage shares	0.651	0.757	0.732	0.669	0.815	0.780	0.763	0.738
Fo Shan Light	0.863	0.752	0.154	0.790	0.714	0.548	0.844	0.666
Wei Fu High-Tec	0.821	0.716	0.730	0.788	0.842	0.727	0.681	0.758
Chinese Nuclear Science	0.659	0.191	0.758	0.815	0.716	0.855	0.874	0.695
Shan Da Wit science and Tech	0.548	0.650	0.759	0.806	0.754	0.779	0.740	0.719
Beijing Capital Land	0.240	0.760	0.814	0.751	0.856	0.904	0.566	0.699
TBEA	0.644	0.756	0.863	0.796	0.833	0.824	0.837	0.793
THTF	0.796	0.839	0.745	0.882	0.930	0.785	0.890	0.838
Changzheng Electric	0.404	0.822	0.683	0.639	0.844	0.775	0.773	0.706
Space Electromechanical	0.861	0.716	0.854	0.920	0.773	0.844	0.476	0.778
Ju Hua Shares	0.839	0.611	0.782	0.839	0.799	0.737	0.835	0.777
The Great Wall Electrician	0.639	0.828	0.895	0.770	0.853	0.672	0.659	0.759
Jiangsu Sunshine Group	0.734	0.763	0.838	0.730	0.813	0.819	0.853	0.793
Zhejiang Sunshine Group	0.828	0.896	0.861	0.870	0.792	0.699	0.896	0.835
Erdos	0.791	0.829	0.714	0.826	0.845	0.709	0.515	0.747
Yan Tai Wan Hua	0.908	0.783	0.878	0.846	0.815	0.893	0.754	0.840
Nan Hai Development	0.824	0.646	0.802	0.766	0.758	0.412	0.843	0.722
Aram too Industrial	0.726	0.822	0.816	0.415	0.876	0.825	0.683	0.738
Longking Environment	0.545	0.810	0.775	0.774	0.533	0.555	0.767	0.680
NARI-TECHNOLOGY	0.785	0.819	0.682	0.825	0.792	0.754	0.851	0.787
Hunan Electric Shares	0.820	0.754	0.619	0.549	0.760	0.316	0.273	0.584
Willow of Shares	0.741	0.618	0.717	0.675	0.749	0.689	0.801	0.713
China Lu Heng Sheng	0.733	0.819	0.653	0.772	0.781	0.784	0.745	0.755
Vhguang Shares	0.454	0.732	0.760	0.695	0.862	0.840	0.754	0.728
Shuangliang Shares	0.804	0.735	0.766	0.814	0.406	0.741	0.871	0.734
Incredible Electrical	0.672	0.619	0.740	0.854	0.871	0.801	0.898	0.779
Fei Da Environment	0.579	0.758	0.864	0.647	0.717	0.867	0.506	0.705
Tianwei Baobian Electric	0.647	0.735	0.861	0.829	0.862	0.753	0.723	0.773
Synyard	0.730	0.875	0.543	0.671	0.781	0.863	0.861	0.761
TELLHOW	0.737	0.821	0.667	0.874	0.680	0.869	0.710	0.765
Three Aifu	0.879	0.808	0.784	0.859	0.886	0.817	0.779	0.830
Shenergy Company LimTEd	0.832	0.750	0.855	0.835	0.845	0.862	0.856	0.834
Sichuan Cast Holding	0.686	0.845	0.801	0.876	0.767	0.647	0.252	0.696
ST	0.796	0.817	0.623	0.845	0.850	0.870	0.826	0.804
Capital Environment Protection Group	0.858	0.816	0.831	0.914	0.568	0.801	0.700	0.784
Oriental Inotor	0.755	0.492	0.800	0.790	0.866	0.818	0.746	0.752
The Company Mean	0.720	0.747	0.750	0.770	0.785	0.755	0.730	0.751
The Standard Deviation	0.142	0.126	0.130	0.114	0.103	0.127	0.159	-
Coefficient of Variation	0.197	0.169	0.173	0.148	0.131	0.168	0.218	-

2.1 The Analysis of the Low Carbon Enterprises' TE in China

The result of the table 1 reveals that: (1) From 2003 to 2007, the average TE is 0.751. It reflects that under the current technical status, the output will increase 24.9% if the low carbon enterprises would raise their efficiency of TE without the increase of labor and capital. That is there is a large room for the low carbon enterprises to enlarge the output. The TE rises from 0.720 to 0.730 during the 7years. It reflects that there is a room to improve the TE

of low carbon enterprises in China.

From the standpoint of the enterprise, YanTai WanHua's average TE is the highest, and THTF follows. The Hunan Electric Shares' is the lowest.

From the standpoint of TE, Zhong Cheng manage shares and Chinese Nuclear Science both have the tendency to increase, however, Southern Glass A, Wei Fu High-Tec etc all have the tendency to decrease; Others are all fluctuating around the low status. Apparently, the coefficient of variation parameter increases periodicity from the standpoint of differentiations of TE. That means the variability of TE has the tendency to increase. In order to vividly describe the development model of low carbon enterprises, this article adopts SPSS17.0 (Using K-means) to analyze the TE and the average input of capital and labor.

Table 2
SFA Result of the Influential Factors to Low Carbon Enterprises in China

	coefficient	The Standard Deviation	T Test Value
Frontier production function			
β_0	-0.595*	0.363	-1.637
β_1	0.850***	0.033	25.622
β_2	0.051*	0.032	1.619
Technical inefficiency function			
δ_0	-7.022*	5.079	-1.383
δ_1	-6.158*	3.711	-1.659
δ_2	0.550**	0.309	1.776
δ_3	2.133*	1.306	1.632
δ_4	1.393	1.410	0.988
δ_5	-0.038	0.077	-0.495
γ	0.952***	0.0303	1.660
Log function value		-185.412***	
Sigle-side LR test		19.168***	
The number of sample		259	
year		7	
The number of cross-section		37	
Average efficiency		0.751	

Table 2 reveals that:

(1) The elasticity of the enterprise's fundamental element and the effect of the enterprise's scale $\beta_1 = 0.850$, it means the output elasticity of capital is 0.850; $\beta_2 = 0.050$, the output elasticity of labor is 0.051. That means if the number of employee increased 1%, the output will increase 0.051%. Thus, the development of low carbon enterprises are mainly driven by the investigation of capital — the increase of output is mainly caused by the increase of capital, therefore, the development pattern of low carbon enterprises is still the extensive one of economic growth. In addition, the total of output elasticity of capital and labor is 0.901, and is smaller than 1. It means the development of low carbon enterprises is still lack of scale economy.

(2) Fund utilizing capacity

The coefficient number of total assets turnover rate is below the zero, and it is apparent on the level of 10%. It means there is a positive relationship between TE and fund utilizing capacity of low carbon enterprises. The larger the total assets turnover rate is, the stronger the fund utilizing capacity is, and the higher of TE. The readily marketable of a product, the perfect distribution channel, and the maximum of the earnings through making best of available assets are all contribute to the result. Thus, in order to increase TE, low carbon enterprises should clarify the position of the production in the market, and increase the fund utilizing capacity.

(3) The influence of technical capacity

The ratio of technical employee is positive, and it passes the examination by the level of 5%. It reveals that there is a negative relationship between the TE and the technical capacity. According to this article, two reasons contribute to this phenomenon. Firstly, there are too many technical employees lay aside, and low utilization of technician because of the expansion of the scale and annex and recombination. Secondly, the quality of the technician is not high enough, and the number of qualified technician is a little. All these factors have negative influence on the innovation ability and the efficiency of production.

(4) The influence of enterprises' scale

The positive coefficient of the enterprises' scale passes the examination on the level of 10%, and it means there is a negative relationship between TE and the scale of the enterprises. That is to say, the larger the average scale is, the lower efficiency of the economy scale is. The reason attribute to the phenomenon is the complexity of inner construction which caused by the expansion of the scale. The advantages and disadvantages brought by the expansion of the scale is equal to each other. Thus, low carbon enterprises should pay more attention to the increase of the technical and management ability, instead of the scale.

(5) The influence of the capital structure

The positive coefficient of enterprise's scale indicates the negative relationship between the TE and capital structure. The result reveals that the capital structure restrains the increase of TE, but the influence is not apparent. Thus, low carbon enterprises should optimize the capital structure to maximum the value of the enterprises and increase TE.

(6) The relationship between the time and TE

The time trend coefficient of inefficient function is -0.038. It indicates that the technical inefficiency decreases from year to year, and it makes the TE increase year by year, at eh same time, it stimulates the improvement of TE. But, the coefficient doesn't pass the examination, and it indicates that the increase of TE is not a natural process by time. It is influenced by the environment, and it varies from time to time. Thus, the degree of technical inefficiency of low carbon enterprises decreases, but the tendency is not obvious.

CONCLUSION & INSPIRATION

This article analysis TE and its influential factors of low carbon enterprises, and it is based on the panel data from listed-firms at the period of 2003 to 2009, using stochastic frontier function model of Cobb-Douglas. The research reveals that the capital, instead of the labor, mainly contributes to the increase of output of low carbon enterprises. The increase pattern is still the extensive one, and the economy is lack of the economy scale. Fund utilizing capacity has positive influence on TE, but the technical capacity and the enterprise's scale have negative influence on TE. Even though the capital structure, to some extent, restrains the increase of TE, the influence is not obvious. The technical inefficiency decreases from year to year, but this tendency is not apparent. The development pattern of low carbon enterprises is "low input, high efficiency" and "low input, low efficiency".

From 2003 to 2009, the capital contributes 85% to the increase of TE, the labor is 5.1%, and the average efficiency is 0.751, therefore, it is capital that increases TE OF low carbon enterprises. Besides, the output elasticity of capital is higher than that's of labor, and it indicates that the low carbon enterprise is lack of labor. The enterprises should bring in the foreign investment, widen the fund raising channel, and make the best of the capital structure to increase TE. On the other hand, the conclusion reveals that low carbon enterprises doesn't lack of labor, but the ratio of technician is so low that restrains the advantages which brought by the plentiful of the labor. Moreover, the quality of technician is not high enough, and the qualified technician is still at the shortage. This phenomenon would influence the expansion of scale and economy scale, therefore, low carbon enterprises should, on one hand, increase the ratio of qualified employees; on the other hand, pay attention to the quality of all employees. Only through this way, does the enterprise can increase the influence of labor.

From the conclusion above, the article advise that the development with the efficiency and productivity of low carbon enterprises should not only depend on the increase of capital and labor, but also take TE into consideration. In order to increase TE, low carbon enterprises should continually improve the fund utilizing capacity, optimize the technical capacity, improve the capital structure, and keep a balance between efficiency and scale. At the same time, low carbon enterprises should transfer the development pattern, and development and efficiency of technology, instead of capital, the mainly factors that stimulate the increase of output of production.

REFERENCES

[1] Johnston, D, Lowe, & R, Bell, M. (2005). An Exploration of the Technical Feasibility of Achieving CO_2 Emission Reductions in Excess of 60 % Within the UK Housing Stock by the Year 2050. *Energy Policy, 33*.

[2] Kawase, R, Matsuoka, Y, & Fujino, J. (2006). Decomposition Analysis of CO_2 Emission in Long-Term Climate Stabilization Scenarios. *Energy Policy, 34*.

[3] Koji Shimada, Yoshitaka Tanaka, Kei Gomi, & Yuzuru Matsuoka (2007). Developing a Long Term Local Society Design Methodology Towards a Low-Carbon Economy: An Application to Shiga Prefecture in Japan. *Energy Policy, 35*.

[4] FENG Zhijun, & NIU Wenyuan (2009). Low Carbon Economy and Scientific Development. *Soft-science of China, 8*.

[5] XIA Ning, & XIA Feng (2009). Low Carbon Economy and Green Development Strategy—The Dedication of the First Special Environment Zone in Nan Hai. *Soft-Science of China, 10*.

[6] CHEN Xiaochun, HU Ting, & TANG Yijun (2010). The Research on the Development of Low Carbon Economy in China. *China Science Forum, 2*.

[9] SONG Bangying, & SU Fanglin (2010). An GWR Empirical Study on the Output of Carbon and the Development of the Economy in China. *Financial Science, 4*.

[10] ZHOU Yuanchuan, & ZOU Ji (2009). The Dedication on Influential Factors and Strategy of the Development of Low Carbon Economy in China. *Statistic and Strategy, 23*.