Energy Efficiency Evaluation Analysis of the Three Urban Agglomerations in China

Hu Biao[1], Sun Xue[2]

[1]Industrial Engineering, School of Management, Tianjin University of Technology, 300384 China

[2]Industrial Engineering, School of Management, Tianjin University of Technology, 300384 China

Corresponding author；13370306755@163.com

Abstract. In this paper, the energy efficiency of the three urban agglomerations in 2006-2015 was evaluated with the combination of the undesired output of SBM model and Malmquist index. The research shows that the overall development of energy efficiency of the three urban agglomerations is an upward trend, and the trend of energy efficiency of each urban agglomeration is different and shows certain characteristic. The technical progress index has significant influence on the development trend of M index.

1.The introduction

In recent years, urban agglomeration constantly pursue rapid economic growth, excessive concentration and exploitation of energy, the environment is getting worse, and the ecology tends to be imbalanced[1]. To prevent this kind of phenomenon out of expanding, increasing energy efficiency, achieving energy conservation and reducing emissions are at the present stage in our country, saving energy, protecting environment and maintaining sustainable development are the major goals [2].   In 2015, China's GDP accounted for 21.4% of the world, but 38.7% of the GDP was occupied by energy consumption, low efficiency of energy utilization made our country face a heavy pollution, high emissions and low efficacy quo, it was unfavorable for developing economy, and it impeded green development even more[3]. How to improve energy efficiency while improving economic growth is a major problem that market economy society needs to solve urgently. Therefore, in the guarantee to improve the ecological environment, optimizing energy efficiency and grow the economy with a green, coordinating and steady step, make a great significance to energy utilization and recycling in China. Based on the data plate of the Beijing-Tianjin-Hebei, the Yangtze River delta and the Pearl River delta urban agglomeration, the paper delved cycle economic efficiency status and differences of the three urban agglomerations in 2006-2015 with the undesired output of SBM model and Malmquist index.

2. Research methods and areas

2.1 The research methods

2.1.1 The undesired output of SBM model

Tone puts the input and output slack variables directly into the target function, which build the non-radial and non-angle of SBM efficiency evaluation model [4]. The specific expression is as follows:

$$\rho_i^* = \min\rho = \frac{1 - \left(\frac{1}{m}\sum_{m=1}^m s_m^x \big/ x_{m'}^i\right)}{1 + \left[\frac{1}{n}\sum_{n=1}^n s_n^y \big/ y_{n'}^i\right]} \quad (1)$$

$$\text{s.t.} \sum_{i=1}^i y_n^i - s_n^y = y_n^{k'}, n = 1, \cdots, N; \quad (2)$$

$$\sum_{i=1}^i x_m^i + S_m^x = x_m^{i'}, m = 1, \cdots, M; S_n^y \geq 0, S_m^x \geq 0, i = 1, \cdots, I \quad (3)$$

On type, only the evaluation unit is effective when $\rho_I^* = 1$ and $s = 0$. There is no redundancy in input and insufficient output. Otherwise, there is redundant input and insufficient output, and need to be further improved.

2.1.2 Malmquist index

Malmquist productivity index was proposed by Malmquist in 1953. The specific model is as follows:

$$M(x^t, y^t, x^{t+1}, y^{t+1}) = \left[\frac{D^t(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)} \times \frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^{t+1}(x^t, y^t)}\right]^{1/2} \quad (4)$$

When M>1, the total factor productivity is on the rise. When M=1, the total factor productivity remain the same. When M<1, the total factor productivity showed a downward trend [5].

3.Empirical results and analysis

3.1 Energy efficiency analysis of the three urban agglomerations

As shown in figure 1, the mean of energy efficiency of Beijing-Tianjin-Hebei, Yangtze River delta, Pearl River delta and comprehensive are 0.847, 0.874, 0.924 and 0.882. The efficiency of Beijing-Tianjin-Hebei area has increased from 0.805 in 2006 to 0.910 in 2015, rose 12.94% and reached the lowest level of 0.813 in 2010. The efficiency of the Yangtze River delta area has increased from 0.822 in 2006 to 0.924 in 2015, up 12.34%. During the 12th five-year plan period, the Yangtze River delta urban agglomeration has not dealt with the waste and pollutant caused by production in time while developing economy rapidly, and it impedes the growth of energy efficiency. The mean efficiency of the Pearl River delta area has increased from 0.894 in 2006 to 0.974 in 2015, up 8.96%. While developing the economy, the Pearl River delta urban agglomeration has increased its investment in environmental governance, so that energy has been well utilized, and ecology has been actively protected. The comprehensive average efficiency has increased from 0.841 in 2006 to 0.936 in 2015, up 11.3%. Although the Pearl River delta energy use is proper while the development is better, but the Beijing-Tianjin-Hebei region is densely populated, have too much waste and living garbage, leading to the ecological imbalance. The energy efficiency of the three urban agglomerations develops slowly and the efficiency value is low.
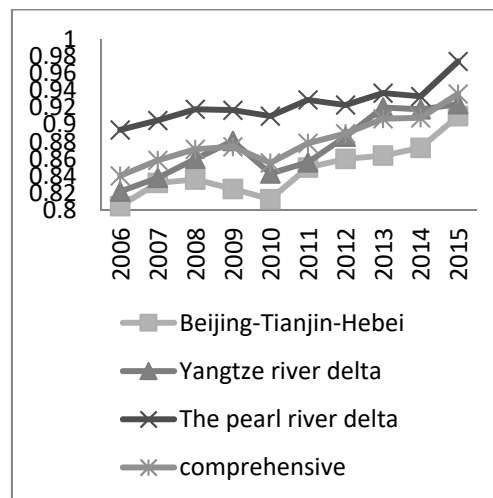
FIG. 1. Energy efficiency trend chart of the three urban agglomerations

In this paper, the mean of energy efficiency of cities in 2006-2015has been divided into five levels: low efficiency zone (0.750-0.800), a little low efficiency zone (0.800-0.850), medium efficiency zone (0.850-0.900), a little high efficiency zone (0.900-0.950) and high efficiency zone (0.950-1.000).

3.2 Analysis of internal energy efficiency of urban agglomeration

Table 2 shows that Beijing and Tianjin in Beijing-Tianjin-Hebei urban agglomeration are in the high efficiency zone. The mean efficiency of Shijiazhuang is in the middle efficiency zone. Tangshan, Baoding, Qinhuangdao and Cangzhou are in the low efficiency zone. The mean efficiency of Langfang, Zhangjiakou and Chengde is in the low efficiency zone. The average energy efficiency of most cities is lower than that of the medium-efficiency zone in Beijing-Tianjin-Hebei urban agglomeration. Therefore, China has issued "Outline of Beijing-Tianjin-Hebei coordinated development plan". We will continue to transform the economic development model, improve the industrial structure, and expand the scale of economic development. The role of core cities paly to the largest and promote the development of surrounding cities.

Shanghai and Hangzhou of the Yangtze River delta are in high efficiency. There are five cities in a little high efficiency zone, including Nanjing, Ningbo, Hefei, Suzhou and Yangzhou. There are eleven cities in the middle efficiency zone, respectively, Wuhu, Jinhua, Huzhou, Ma 'anshan, Shaoxing, Tongling, Anqing, Jiaxing, Zhenjiang, Chuzhou and Xuancheng. Seven of the remaining cities are in a little low efficiency zone, and only one city is in the low efficiency zone. More than eighteen cities are in middle efficiency above of the Yangtze River delta urban agglomeration, accounted for 69.2%, the overall development of the energy efficiency has achieved good result.

The mean energy efficiency of Guangzhou and Shenzhen in Pearl River delta urban agglomeration is in high efficiency zone, account for 22.2%. There are four cities where the mean energy efficiency is in a little high zone. The rest of cities are in the middle efficiency zone, account for 33 %. The internal and external development of the Pearl River delta city clusters is balanced and steadily rising.

Table 1. Average energy efficiency of 45 cities from 2006 to 2015

CITY	MEAN	CITY	MEAN	CITY	MEAN
Beijing	0.976	Nantong	0.810	Maanshan	0.868
Tianjin	0.965	Yancheng	0.840	Tongling	0.858
Shijiazhuang	0.876	Yangzhou	0.915	Anqing	0.857
Tangshan	0.837	Zhenjiang	0.854	Chuzhou	0.851
Baoding	0.832	Taizhou	0.816	Chizhou	0.838
Langfang	0.788	Hangzhou	0.975	Xuancheng	0.851
Qinhuangdao	0.822	Ningbo	0.941	Guangzhou	0.986

Cangzhou	0.816	Jiaxing	0.857	Shenzhen	0.975
Zhangjiakou	0.775	Huzhou	0.880	Zhuhai	0.933
Chengde	0.782	Shaoxing	0.864	Fuoshan	0.914
Shanghai	0.985	Jinhua	0.884	Jiangmen	0.908
Nanjing	0.949	Zhoushan	0.830	Zhongshan	0.893
Wuxi	0.798	Taizhou	0.848	Dongguan	0.944
Changzhou	0.821	Hefei	0.929	Huizhou	0.888
Suzhou	0.928	Wuhu	0.890	Zhaoqing	0.873
Beijing-Tianjin-Hebei	0.847	Yangtze river delta	0.874	Pearl River delta	0.924

3.3 Malmquist index analysis

Table 3 shows that the mean of M index is 1.073 from 2006 to 2015, up 7.3%. There are four periods in which M index is less than 1, five periods in which M index is more than 1.Ten years, the mean of EFC is 1.078, rose 7.8%.The mean of TC is 0.992,drop 0.8%. TC is mainly affected by SC. On the whole, the M index varies mainly with the change of the EFC.

Table 2. Energy efficiency change analysis of the three urban agglomerations from 2006 to 2015

YEAR	M index	EFC	TC	PC	SC
2006/2007	0.945	0.885	1.007	0.967	1.046
2007/2008	0.968	0.894	1.018	0.951	1.002
2008/2009	1.105	1.107	0.956	0.948	0.951
2009/2010	0.987	0.993	0.952	0.994	0.983
2010/2011	1.124	1.114	0.976	1.018	0.955
2011/2012	1.213	1.083	1.017	1.136	1.014
2012/2013	0.993	1.113	1.027	1.025	0.988
2013/2014	1.109	1.215	1.022	1.029	0.975
2014/2015	1.216	1.294	0.956	1.083	0.962
MEAN	1.073	1.078	0.992	1.017	0.986

4.Conclusion

The overall development of energy efficiency of the three urban agglomerations in ten years is on the rise. The mean efficiency trend of Beijing-Tianjin-Hebei and Yangtze River delta region is fluctuation and up type. The mean efficiency of the Pearl River delta region belongs to steady type. The inner development gap of Beijing-Tianjin-Hebei urban agglomeration is large, and imbalances are prominent. The inner development of Yangtze River delta urban agglomeration is relatively balance, and Zhejiang is better than the other two provinces at developing and improving energy efficiency. The energy efficiency of Pearl River delta urban agglomeration develops rapidly and stably. The improvement of total factor productivity of the three urban agglomerations has driven by technological progress.

References

[1]Xiaojun Ma, Xiaoxue Wei, Chao Liu, Yaxue Liu. Energy efficiency measurement and influence factor analysis of the three northeastern provinces. J. China environmental science .37(2017)

[2]Shouwu Jing, Jie Zhang. Analysis on convergence of energy environmental efficiency between provinces in China .J. Journal of Shanxi University of Finance and Economics .40(2018)

[3]Enping Li, Jinyu Guo. Spatial statistical analysis of the differences in energy efficiency between provinces in China .J. Statistics & Decision .06(2017)

[4]Zhongmin Liu, Wenting Ma. Research on innovation efficiency and influencing factors of pharmaceutical manufacturing industry based on network sbm-malmquist model .J. Science

and Technology Management Research .37(2017)

[5]Haiyue Chen. Analysis of regional energy efficiency and its influencing factors in China -- based on dea-malmquist model .J. Journal of GuiZhou University of Finance and Economics .06(2017)