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Efficiency Analysis of China's Water Industry: Evidence From the Cross-National Comparison and Listed Companies

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Abstract
This paper estimates the efficiency of 108 water listed companies in China, U.S.A, and U.K by using the metafrontier model from 2015 to 2018. The results show that the technical efficiency of China's urban water industry is relatively low. But the water industry efficiency gap between China and the world is narrowing.

Key words: Efficiency; DEA; Metafrontier; Cross-national comparison; Listed companies

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INTRODUCTION

Water industry is an important sector of public utilities in a country. How to improve the comprehensive efficiency of urban water industry has always been one of the focuses of attention of governments. China is a developing country with more people and less water. Its per capita freshwater resources are only one fourth of the world's per capita. Therefore, improving the efficiency of urban water industry have become the key links of water resources management in China.

In order to improve the efficiency of municipal public utilities such as urban water, the Chinese government formally initiated the market-oriented reform of municipal public utilities at the end of 2002, encouraged private capital to invest in the water industry, and accelerated the development of the water industry. China's urban water industry has achieved "pulse" development. However, the development of water industry is only due to the expansion of the scale of the industry, or the overall efficiency of the water industry has also been improved, which still needs further theoretical research and rigorous empirical testing. Some scholars believe that the efficiency of water enterprises after the market-oriented reform has been improved (Saal, et al, 2007), while some scholars believe that the efficiency has not improved, but has declined (Molinos-Senante, et al, 2015), and there is no agreement. To answer whether the efficiency of a country's water industry has been improved, further empirical tests are needed.

This paper will use DEA and metafrontier method to make an cross-national comparative study on efficiency of water listed companies in China, U.S.A and U.K from 2015 to 2018, in order to discuss the improvement of efficiency in China's urban water industry.

METHODOLOGY AND DATA

Firstly, suppose that each water company during the period t (t=1, 2, ..., T) uses N kinds of inputs $x_t = (x_{1t}, x_{2t}, ..., x_N) \in R_N^+$ to produce M kinds of desirable outputs $y_t = (y_{1t}, y_{2t}, ..., y_M) \in R_M^+$. We assume that decision making units (DMUs) can be divided into g ($g = 1, 2, \ldots G$) groups. Therefore, the production possibilities set (PPS) in each group can be expressed as follows:

$$P_t^g(x) = \{(x_t^g, y_t^g): x_t^g \text{ can produce } y_t^g\} \quad (1)$$

Under the condition of covering all samples, a metafrontier PPS enclosing all groups can be constructed as follows (Battase et al., 2004; O'Donnell et al., 2008) :

$$P_t^M(x) = \{(x_t, y_t): x_t \text{ can produce } y_t\} \quad (2)$$

The direction vector $\overset{\varpi}{g} = (g_x, g_y)$ indicates the direction of input and output change. β is the maximum feasible quantity of inputs, desirable outputs by increasing and reducing the same proportion to the production frontier.

Correspondingly, distance functions (DF) with respect to group and metafrontier are respectively:

$$\overset{\omega}{D}{}_t^g(x_t^g, y_t^g; \overset{\varpi}{g}) = \sup\{\beta : (x, y) + \beta\overset{\varpi}{g} \in P_t^g(x, y)\} \quad (3)$$

$$\overset{\omega}{D}{}_t^M(x_t, y_t; \overset{\varpi}{g}) = \sup\{\beta : (x, y) + \beta\overset{\varpi}{g} \in P_t^M(x, y)\} \quad (4)$$

The larger the DF is, the farther the distance between the DMU and production frontier is. When DF is zero, the DMU is on the production frontier. Since the DMU is to increase outputs while reducing inputs, so the DF based on DEA method with variable returns to scale can be expressed as:

Thus, the efficiency of water utility can be computed

$$\begin{aligned} &\overset{\omega}{V}(x_t^{k'}, y_t^{k'}; -x_t^{k'}, y_t^{k'}) = \max \beta \\ &s.t. \sum_{k=1}^{K} \lambda_t^k y_t^{km} \geq (1+\beta) y_t^{k'm}, m = 1,2,\Lambda, M; \\ &\sum_{k=1}^{K} \lambda_t^k x_t^{kn} \leq (1-\beta) x_t^{k'n}, n = 1,2,\Lambda, N; \quad (5) \\ &\sum_{k=1}^{K} \lambda_t^k = 1, \lambda_t^k \geq 0, k = 1,2,\Lambda, K \end{aligned}$$

by this formula:

$$TE = \frac{1}{1+DF} \quad (6)$$

while Technology gap ratio (TGR) measures the distance between group frontier and metafrontier, which is $TGR = \frac{TE_M}{TE_G}$. TE_M. TE_M is technical efficiency of metafrontier, TE_G is technical efficiency of group frontier.

The higher the TGR of a water plant is, the closer the group production level (actual production level) is to the potential production level, that is, the higher the technical level is. Since the average TGR of all water plants in a country reflects the gap between the actual and potential technology levels, this indicator can be also used as the gap between a country and world's frontier that is comprised of sample countries.

We calculate 108 water listed companies in China, U.S.A and U.K from 2015 to 2018. All data is collected from Wind database. Referring to previous studies (Molinos and sala, 2016; Ruan and Han, 2016), we choose the operation cost, staff and total assets as inputs, while outputs are the revenue and the profit.

EMPIRICAL ANALYSIS

Kruskal-Wallis nonparametric test is used to verify the heterogeneity of production frontier (Tsagarakis, 2013). The result of Kruskal-Wallis nonparametric test shows that efficiency analysis based on a single production frontier assumption can not analyze the efficiency of water listed companies from China, U.S.A and U.K.

After verifying the heterogeneity of the production frontier of the three countries, this paper calculates the group frontier efficiency and the metafrontier efficiency of them from 2015 to 2018, and calculates the average and standard deviation, as shown in Table 1.

Firstly, for the efficiency of group frontier, the average of each country are all over 0.9. The annual average standard deviation of group frontier efficiency value shows that U.K standard deviation is the smallest, while China's standard deviation are more higher. On average, the group frontier efficiency is higher than the metafrontier efficiency. For example, the average value of group frontier efficiency in China is 0.921, which means that there is room for improvement of the operation cost input of water plants in China to reduce by 8%.

As far as we know, there are few literature on the efficiency comparison of China's water industry. Liu et al. (2013) estimated the efficiency of water system in 33 provincial areas using CRS and VRS assumptions. The average efficiency under CRS assumption is 0.852, 11 provinces are in the effective border, and the average efficiency under VRS assumption is 0.978, which is in the range of 0.852. There are 19 provinces with effective borders. Molinos and Sala (2016) estimated that the average frontier efficiency of the Chinese group was 0.77. The average group frontier efficiency of China's water listed companies between 2015 and 2018 estimated in this paper is 0.921, which is quite different from the results of the previous studies.

Table 1
DEA estimates of technical efficiency with respect to group frontiers and to the metafrontier

	Efficiency score with respect to group frontiers			Efficiency score with respect to the metafrontier		
	Mean	S.D.	Efficiency	Mean	S.D.	Efficiency
China	0.9214	0.1047	65%	0.7798	0.2260	38.33%
U.S.A	0.9532	0.0869	80.56%	0.9476	0.2670	94.44%
U.K	0.9943	0.0098	91.67%	0.7370	0.0540	41.67%

Next, we compare the number of effective manufacturers at the production frontier in each country. The left column of Table 1 below shows that the effective companies in China, U.S.A and U.K are all over 50%. This paper estimates that the proportion of effective manufacturers in China is 65%, which means that 35% of China's water listed companies have room for improvement in input or output.

The second step is to make a comparative analysis of the efficiency of countries with respect to the metafrontier. As the theory reveals, the metafrontier efficiency is lower than group efficiency, as shown in Table 1. However, the reduction of technical efficiency values for different frontier measurements is also very different for countries. U.K have the greatest reduction in the efficiency of the two kinds of frontier measurement, with China falling by 0.15 and U.S.A by 0.1. Under the metafrontier, the number of effective manufacturers in U.K and China has also decreased significantly, while U.S.A having more effective companies. This again demonstrates the importance of using the metafrontier to measure the cross-national technical efficiency differences.

TGR ANALYSIS: IS THE GAP BETWEEN CHINA AND THE WORLD IN WATER INDUSTRY NARROW?

Technology gap ratio (TGR) reflects the gap between one country's production technology and the world's production technology frontier. The bigger the technology gap ratio is, the smaller the gap between the country's production technology frontier and the world's production frontier is, which is one of the important indicators to measure the technology gap. At the same time, the changing trend of technology gap ratio, such as the bigger and bigger, means that the country's production technology keeps approaching the world's leading edge, indicating that there is obvious technological progress in the country.

Figure 1 shows that the technology gap ratio of China's urban water industry is on the rise in general, indicating that the gap in water industry between China and U.S.A, U.K is decreasing, and there is obvious technological progress in China' water industry.

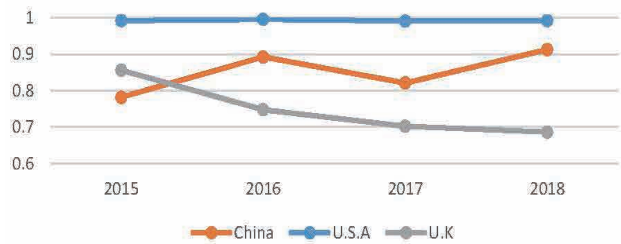

Figure 1
Trends in TGR of water industry in countries from (2015-2018)

Next, this paper uses the indicators of pure technology catch-up (abbreviated as PTCU) to further analyze the evolution of technology gap in the three countries' water industry (Wang and Zhu, 2011).

$$PTCU = \frac{TGR_{t+}}{TGR_t} \quad (7)$$

When the PTCU is greater than 1, it means that the gap between the production technology of the water enterprise and the world's potential technology is narrowed, and there is a technology leading effect. We make a detailed analysis of the average value of the PTCU index of each listed water company in China. The results shows that all listed water companies in China, which reflect the technology leading effect, have outstanding performance in the field of sewage treatment and environmental protection, and their business has a large growth. The reason may be that in the 13th Five-year Plan, China has paid more and more attention to sewage treatment and environmental protection business, and some water listed enterprises have increased technological innovation and investment that helps improving efficiency.

CONCLUSIONS

From the perspective of cross-national comparison, this paper considers the heterogeneity of enterprises and estimate the efficiency of 108 water listed companies in China, U.S.A and U.K from 2015 to 2018. From a cross-national perspective, the gap between China and the world in water industry has narrowed in the 13th Five-year Plan, and the sewage treatment and environmental protection business helps water listed companies in china improved efficiency further.

REFERENCES

Battese, G. E., Rao, D. S. P., & O'Donnell, C. J. (2004). A met frontier production function for estimation of technical efficiencies and technology gaps for firms operating under different technologies. *Journal of Productivity Analysis, 21* (1), 91-103.

Liu, Y., Sun, C., & Xu, S. (2013). Eco-effificiency assessment of water systems in China. *Water Resour Manag, 27* (14), 4927-4939.

Molinos-Senante, M., & Sala-Garrido, R. (2016). Cross-national comparison of efficiency for water utilities: a met frontier approach. *Clean Technologies & Environmental Policy, 18*(5), 1-9.

Molinos-Senante, M., Maziotis, A., & Sala-Garrido, R. (2015). Assessing the relative efficiency of water companies in the English and welsh water industry: a metafrontier approach. *Environmental Science & Pollution Research, 22*, 16987-16996.

O'Donnell, C. J., Rao, D. S. P., & Battese, G. E. (2008). Metafrontier frameworks for the study of firm-level efficiency and technology ratios. *Empirical Economics, 34* (2), 231-255.

Ruan, D. F., & Han, L. H. (2016). Performance evaluation of listed water utilities companies based on DEA model. *Resources & Industries, 18*(4), 103-109.

Saal, D. S., Parker, D., & Jones, T. W. (2007). Determining the contribution of technical change, efficiency change and scale change to productivity growth in the privatized English and welsh water and sewerage industry: 1985-2000. *Journal of Productivity Analysis, 28*, 127-139.

Tsagarakis, K. P. (2013). Does size matter? Operating cost coverage for water utilities. *Water Resour Manag, 27* (5), 1551-1562.

Wang, B., & Zhu, N. (2011). Research on the efficiency and total factor productivity of China's Listed Commercial Banks under the constraint of non-performing loans: An empirical analysis based on the directional distance function of SBM. *Financial Research, 367* (1), 110-130.