Influence of Industrial Transfer on Green Efficiency of China's Industrial Sector

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Abstract: Based on the provincial panel data from year 2006 to 2015, the paper uses the SBM-undesirable model to calculate the Chinese regional industry's green efficiency. Then the Spatial Lag Model (SLM) are adopted to figure out the green efficiency's influencing factors including industrial transfer. The empirical results show that the Chinese industrial green performance is not yet efficient, even showing a decline trend in volatility, and there is big difference among the three big areas of China, ranking from high to low: the East, the Central and the West. Finally it is proved that both the industrial transfer and environmental regulation factors fail to promote the industrial green efficiency, and only technological progress, especially the green technology, has played a positive role.

1. Introduction

To balance the regional economic development, Chinese government is guiding investments flowing to China's central &western areas by issuing more preferential policies [1]. Moreover, in recent years, the coastal areas of China are experiencing the pain of rising land and labor costs, coupled with weak international market demand since the Economic Crisis, the industrial enterprises in coastal areas are facing big challenges in making sustainable profits[2]. Under this background, more and more eastern coastal industrial enterprises are accelerating the pace of transfer to the central &western areas. China's domestic regional industrial transfer is proved to be very active from the east to the central &western areas, which on the one hand can positively help the eastern industry to divert away the surplus production capacity and upgrade the industrial structure, and on the other hand can provide the central and western areas with good opportunities for technology progress and industrialization acceleration[3].

However, for the central &western areas, the regional industrial transfer does not only bring advanced technology and equipment, but also lead to excessive energy consumption and environmental pollution[4]. Recently driven by various reasons, the industrial enterprises gradually began to shift to the central &western areas. Meanwhile, the central &western government is eager to attract outside investments to boom local economy, conducting loose environment regulation even zero regulation in specific investment accepting selection [5]. Therefore, in the central &western areas, as more industrial enterprises enter, the industrial energy consumption has increased significantly, and the environmental problems including the discharge of waste gas, waste water, and solid waste also become outstanding. In this context, the domestic regional industrial transfer from the east to the central &western, aiming to narrow economic development gap, is actually reducing the central &western areas to be the typical "Pollution Haven", featured with more energy consumption and serious environmental pollution, resulting in big headache for China's green economic growth.

Thus it makes sense to scientifically evaluate the efficiency of regional industry's green growth and accurately judge the role of domestic industrial transfer: Is China's domestic industrial transfer aggravating the regional gap in industrial green efficiency, or is it having a positive impact of convergence? In addition to industrial transfer, what other influencing factors play decisive roles in the change of such spatial relations? This paper attempts to answer these questions.

2. Measurement of Chinese Regional Industrial Green Efficiency

The industry's green efficiency is an input-output economic efficiency under the constraints of resources and environment, and most studies on input-output efficiency adopt the DEA method. However, the conventional DEA model does not take into account the undesirable output of the actual production process, such as waste water, waste gas and solid waste from industrial production which are by-products not expected in production. In order to deal with the problem of undesirable output, this paper uses the SBM model proposed by Tone [6, 7], and introduces the undesirable output to form the SBM-undesirable model to measure the green efficiency.

In order to better reflect the development of China's regional industrial transfer, we divide China's mainland into three big regions: the East, West and Central. The eastern region including 11 provinces(and municipalities): Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Hainan. The central region including 10 provinces: Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan, Guangxi; and the western region including 10 provinces: Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Ningxia, Qinghai, Xinjiang. Due to some years' missing data Tibet will not be considered here. The targeted study period is from year 2006 to 2015.

The paper makes a more comprehensive measurement on China's regional industrial inputs, which covers 4 aspects: capital, labor, energy consumption and pollution treatment. As for the desirable outputs, this paper, according to Wang and Zhao [8], uses the indicators of total profits and taxes of above-scale industrial enterprises to characterize the industry's desirable output. Moving to the undesirable outputs, we measure the industrial undesirable outputs by synthetically adding up four types of emissions: industrial CO_2 emissions, industrial waste water, industrial waste gas, and industrial solid waste. Many studies on Chinese did not include the industrial CO_2 emissions index for it needs to be estimated [9]. This paper, based on IPCC estimation equation[10-12], approximately estimates the CO_2 emitted from the three fossil fuels' burning in industrial operation.

In this study, Max dea7.0 pro is utilized to carry on the input-output numerical evaluation of the ten year Chinese provincial data. Table 1 shows the result of Chinese regional industrial comprehensive green efficiency by the SBM-undesirable model.

Table 1: Industrial green efficiency.

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Average
East	0.71	0.85	0.85	0.84	0.78	0.76	0.67	0.68	0.60	0.65	0.74
Central	0.46	0.66	0.65	0.67	0.58	0.63	0.66	0.48	0.45	0.34	0.56
West	0.54	0.60	0.55	0.47	0.47	0.49	0.45	0.34	0.34	0.32	0.46

The results show that, considering the undesirable output, the average value of China's industrial comprehensive green efficiency from year 2006 to 2015 only amounts to 0.58, which is far from efficient level, which is 1. This invalid green efficiency suggests that the high-speed Chinese industrialization still remains to be extensive, and the cost is high energy consumption and severe pollution. The green industrial growth has not been realized and there exists huge waste of resources, not conducive to the economic sustainable development. The regional results show that the industrial green efficiency varies greatly among different regions, with the East, Central and West ranking from high to low, which is consistent with most of the existing research results. In the last ten years, industrial green efficiency of the eastern region has been slightly decreased, but in recent years shows a rising trend. While in the central and the western regions, the green industrial efficiency shows an obvious declining trend, and especially in the western region, the green industrial efficiency stays at the lowest level each year, and even presents a pessimistic decreasing trend.

If observing the provinces inside different regions, we find that obvious differences also exist among them. In the eastern region, places like Beijing, Tianjin, Jiangsu and Shanghai behave comparatively better, their industrial green efficiency levels are higher than 0.9, and some even reach 1. But places in Bohai Rim like Hebei and Liaoning behave comparatively weak, their industrial green efficiency levels are fluctuating around 0.5, lowering the average level of the eastern region. In the central region, the average green efficiency level is 0.56, with the efficiency levels of most places staying from 0.5 to 0.6, but two provinces Guangxi and Shanxi having only levels around 0.3, far lower than the Central mean. In Shanxi province, the industrial green efficiency shows particularly severe decline in recent years, which might be explained by this province’s pillar industries with high energy consumption, high pollution and high emissions, such as coal, metallurgy, electric power and chemical industry, exerting considerable negative influence on this province’s resources on environment. In the western region, the backward provinces include Yunnan, Guizhou, Gansu and Ningxia. Ningxia’s industrial green efficiency is the lowest; for this province’s economic development greatly depends on heavy industries, with large energy consumption and substantial influence on environment.

3. Influence of Industrial Transfer on Green Efficiency

This paper, then, selects out five perspectives including the industrial transfer to explore factors influencing the industrial green efficiency in China’s 30 provinces and cities. The specific variables are explained in Table 2.

Table 2: Variables.

Explained variable	Provincial industrial green economy	E
Explanatory variables	Industrial transfer: provincial industrial fixed asset investment transfer index	Tran
	Environmental regulation: ratio of investment on industrial pollution treatment projects to GDP	G
	Technical progress: ratio of R&D expenditures to revenue of above-scale industrial enterprises	Tech
	Foreign direct investment(FDI)：ratio of the added value of foreign invested industrial enterprises to that of all regional above-scale industrial enterprises	F

Based on the above variables, the spatial econometric model is established, as shown Equation (1) and Equation (2).

$$E_i = C_i + \beta_1 Tran_i + \beta_2 G_i + \beta_3 Tech_i + \beta_4 F_i + \rho WE_i + \varepsilon_i \quad (1)$$

$$E_i = C_i + \beta_1 Tran_i + \beta_2 G_i + \beta_3 Tech_i + \beta_4 F_i + (I - \lambda W)^{-1} \mu \quad (2)$$

Equation (1) is the spatial lag model (SLM), and Equation (2) is the spatial error model (SEM), in which ρ 、 λ 、 W respectively represent the spatial lag terms, the spatial error terms and the spatial weight matrices, and the subscript i represents any province in the sample.

Table 3 shows the empirical results. Except for the FDI (F), all other variables show significance. The industrial transfer (Tran), which shows significance in most of the years, has a negative impact on industrial green efficiency. Therefore, it is reasonable to tell that although most of the accepting places have improved their economic output and employment by seizing the industrial transfer opportunity, these accepting places, due to the neglect of energy and environment and the sole focus on GDP performance, failing to set up strict access threshold for outside investment, rush to attract those industrial enterprises with high energy consumption and high pollution emission, resulting in the decrease of local industrial green efficiency. Fortunately, in recent years, China begins to realize the importance of green growth, which leads to changes of industrial transfer as well. The central and western regions pay more attention to the quality of the industries transferred, and rely more on technological innovation and sustainable development concept to promote local economic transition and growth. This can be proved by the recent data which shows that industrial transfer is gradually playing positive role on industrial green efficiency.

Table 3: Results.

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
spatial lag	0.192*	0.182*	0.213*	0.184*	0.217*	0.128*	0.159*	0.229*	0.375*	0.308*
constant	1.277*	1.489*	0.966	0.992	0.816*	0.715	1.012*	0.276	0.242*	0.257
Tran	-1.552*	-1.034*	-0.623*	-1.185*	-0.851**	-0.388	-1.786*	-1.693*	0.651*	0.475
G	-0.287*	-0.311*	-0.131	-0.220*	-0.163	-0.149*	-0.169*	-0.034	-0.086*	-0.111*
Tech	0.240	0.539*	-0.162	0.297*	-0.099	0.168*	0.129	0.334*	0.333*	0.337*
F	0.0002	0.002	0.005	0.006	0.006	0.001	-0.003	0.0001	0.002	0.010
R^2	61.2%	65.2%	43.6%	44.3%	50.3%	49.5%	46.3%	53.6%	41.3%	68.0%
Log likelihood	20.59	31.42	30.32	33.84	39.81	40.18	47.07	19.47	32.72	29.13

*Note: *, ** represent statistical significance at the 5% and 10% levels respectively.*

4. Conclusions

This paper, based on the provincial industrial panel data of China from year 2006 to 2015, employs the SBM-undesirable model considering undesirable outputs, to calculate Chinese regional industry's green efficiency. Then the spatial lag econometric model (SLM) are adopted to figure out the green efficiency's spatial distribution and explore the influencing factors including the industrial transfer. The conclusions of the paper are as follows.

Firstly, although some provinces in the eastern region has reached the efficient level of 1, China as a whole fails to reach the industrial green efficiency, and even showing a downward trend in volatility, which indicates that in the process of China’s rapid industrialization, there is still greater waste of resources and damage to the environment, not conducive to the sustainable development of economy. Secondly, the industrial green efficiency varies greatly among regions, ranking from high to low: the East, Central and West. In the last ten years, the industrial green efficiency in the eastern region has slightly declined, but the industrial green efficiency in the central and the western regions show obvious declining trend. Thirdly, some Chinese provinces have formed stable spatial cluster, showing the feature of "superior-east and inferior-west". The eastern cluster has bigger opportunity to enhance the internal industry’s green efficiency due to the surrounding of places with higher green efficiency. The western part, on the other side, has obstacle in increasing the internal industry’s green efficiency due to the surrounding of inferior places. Fourthly, the Chinese regional industrial transfer has not played a positive role in promoting the industrial green efficiency, and the environmental regulation has also failed to enhance the industrial green efficiency. Only the advance in technology, especially the development of green technology can positively influence the industrial green efficiency.

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References

[1] Chen, J.L. (2014) A study of Influencing Factors of industrial location under the background of regional transfer in China. in International Conference on Social Science (ICSS). Chengdu, China.

[2] Yang, S., (2016) China's regional industrial transfer behavior based on evolutionary game theory. Journal of Discrete Mathematical Sciences and Cryptography, 19(3), 677-690.

[3] Xu, J., et al., (2017) An empirical study on the dynamic effect of regional industrial carbon transfer in China. Ecological Indicators, 73, 1-10.

[4] Qu, Y., et al., (2017) Measuring Green Growth Efficiency for Chinese Manufacturing Industries. Sustainability, 9(4), 637.

[5] Peng, W.B. and W.P. Wu, (2013) Analysis of Pollution Industrial Transfer Based on Environmental Regulation and Public Participation china case. Advances in Management & Applied Economics, 3(4), 11-20.

[6] Tone, K., (2001) A slacks-based measure of efficiency in data envelopment analysis. European Journal of Operational Research, 130(3), 498-509.

[7] Tone, K., (2004) Dealing with undesirable outputs in DEA: a Slacks-Based Measure (SBM) approach. Nippon Opereshonzu, Risachi Gakkai Shunki Kenkyu Happyokai Abusutorakutoshu, 44-45.

[8] Wang, J.L. and R.F. Zhao, (2016) Two-dimensional Evaluation of Circular Economy Efficiency and Quality on China's Steel Industry. Technoeconomics & Management Research, 1,124-128 (in Chinese).

[9] Zhang, J., et al., (2017) Industrial eco-efficiency in China: A provincial quantification using three-stage data envelopment analysis. Journal of Cleaner Production, 143, 238-249.

[10] Zhang, M., et al., (2013) Decomposition analysis of CO2 emissions from electricity generation in China. Energy Policy, 52, 159-165.

[11] Chang, Y.T., et al., (2013) Environmental efficiency analysis of transportation system in China: A non-radial DEA approach. Energy Policy, 58, 277-283.

[12] Wu, J., et al., (2016) Measuring energy and environmental efficiency of transportation systems in China based on a parallel DEA approach. Transportation Research Part D-Transport and Environment, 48, 460-472.