Efficiency Evaluation and Influencing Factors Analysis of Industrial Green Transformation in Hubei Province

Xiao Ying[1*], Xie Rongjun[2,b]

[1]*Wuhan Vocational College of SoftWare and Engineering, Wuhan, Hubei, China*
[2]*Wuhan Vocational College of SoftWare and Engineering, Wuhan, Hubei, China*
**corresponding author: 346701288@qq.com*
[b]*e-mail: 289720360@qq.com*

Abstract

This paper selects 12 major cities in Hubei Province as the research objects. Using the Super-SBM model and GML index to calculate the industrial green transformation efficiency and differences of major cities in Hubei Province from 2009 to 2019.The overall industrial green transformation efficiency level is still at a low level, but there is a clear trend of improvement. There are obvious differences in the level of green total factor productivity among cities. The growth of green total factor productivity in some cities is mainly due to the improvement of technical efficiency. Further use the panel econometric model to analyze the factors affecting the efficiency of industrial green transformation in major cities in Hubei Province. The level of economic development, government support, the improvement of education level and environmental regulation have obvious promoting effects. It is expected that the analysis results have certain theoretical and practical significance for guiding the green development of urban industry.

Keywords*-green transformation efficiency; green total factor productivity; Global Super-SBM model; Global Malmquist - Luenberger Index*

1.Introduction

China's economic development has entered a new stage, that is, the economy has shifted from high-speed growth to high-quality development. Environmentally friendly and resource-saving "two-oriented" society and low-carbon economy have put forward new requirements for economic development. Industry is the basic framework of economic development, so industrial development is of great significance to economic development. At present, the common problems in the process of industrial development, such as low resource utilization efficiency and serious environmental pollution, have received extensive attention and discussion. The concept of green development is a new development model that takes environmental protection as an important pillar of sustainable development under the constraints of ecological environment capacity and resource carrying capacity. Following the concept of green development has gradually become the requirement and goal of industrial development. The transformation of my country's industry is oriented by green development.[1]

Hubei Province is an important industrial base in China. The industrial growth rate of Hubei Province ranks among the top in the country, making a huge contribution to the economic growth of Hubei Province. In 2021, the number of industrial enterprises above designated size in Hubei Province will reach 15,769. The added value of the number of enterprises increased by 14.8%, with an average growth rate of 3.8% in the two years. Although Hubei Province has formed a comprehensive industrial system with relatively complete categories. However, the industrial development of Hubei Province is still characterized by high pollution, high energy consumption and high emissions. From the perspective of resource consumption, compared with domestic advanced cities, Hubei Province's industry is still at a relatively low level in terms of technology and technology of resource utilization efficiency. From the perspective of environmental pollution, the proportion of pollution-intensive manufacturing industries in Hubei Province is relatively high, which weakens the achievements of economic development. The industrial green transformation of Hubei Province is not only an important link in the adjustment of industrial structure, but also an important driving force for promoting the

G. Vilas Bhau et al. (Eds.): MSEA 2022, ACSR 101, pp. 122–130, 2023.
https://doi.org/10.2991/978-94-6463-042-8_20

high-quality development of the regional economy. Improving the efficiency of industrial green transformation by improving resource and environmental issues is an approach that cannot be ignored. Taking the main prefecture-level cities in Hubei Province as the research objects, by quantitatively measuring the efficiency of industrial green transformation in Hubei Province, evaluating the level of industrial green transformation and analyzing the growth of industrial green total factor productivity. By exploring effective ways to improve the efficiency of industrial green transformation in Hubei Province, it will provide effective support for Hubei Province to formulate scientific policies.

2.Research status

The existing literature mainly focuses on the adjustment of urban industrial economic structure and the strategy of industrial transformation. The research on industrial green transformation mainly focuses on the evaluation of industrial green transformation and the factors that drive the development of industrial green transformation. The relevant research on the evaluation of industrial green transformation is as follows. Kou Huanhuan put forward specific suggestions on optimizing the development environment of industrial enterprises through the vertical evaluation of the industrial economic level of Hubei Province from 2009 to 2017 and the horizontal comparison of the industrial economic level of the six central provinces in 2017.[2]Through quantitative analysis of the performance of Hubei's industrial transformation and upgrading, Ye Xueping proposed independent innovation opportunities and strategies for Hubei's industrial transformation and upgrading.[3]By evaluating the development status of resource-exhausted cities in Hubei Province, Li Ming put forward suggestions for exploring the development path of transformation and upgrading from the aspects of industrial structure, corporate financing, talent training, environmental protection, industrial integration, and government functions.[4]Liu Xiping used panel data from 2003 to 2014 to measure the city's green development efficiency and changing trends, providing a reference for some cities in Hubei Province to improve resource utilization efficiency and increase environmental protection.[5]Among them, quantitative evaluation and analysis scholars generally use the analytic hierarchy process, DEA method, etc. Among them, the DEA method can effectively overcome the problems of weight determination and dimension inconsistency. In terms of the influencing factors of industrial green transformation, scholars focus on research from the perspectives of environmental regulation, technological innovation and foreign investment. Yuan Yijun believes that FDI can promote China to strengthen the level of environmental regulation, and then environmental regulation can effectively increase the environmental threshold for foreign investment to enter. In this case, it can promote the growth of industrial green total factor productivity.[6]Yan Hongping's research found that FDI, infrastructure and innovation input have a positive impact on the convergence of China's industrial green total factor productivity index.[7]Chen Yao's research found that industrial scale and industrial output value per unit of energy consumption promote the improvement of industrial green efficiency, while there are regional differences in the impact of R&D input intensity on industrial green efficiency.[8]Xiaoming and others believe that industrial transfer and government regulation cannot improve industrial green efficiency.[9]On the whole, the theoretical analysis and empirical test of the measurement and influencing factors of industrial green transformation in the existing literature provide a useful reference for this paper.

3.Research methods and data description

3.1. Research methods and model selection

DEA model is widely used in the econometric analysis of efficiency.This paper adopts the non-radial and non-angular SBM model, which can better reflect the essence of efficiency evaluation than other models of DEA.The CCR model of undesired output is as follows:

$$\rho^* = \min \frac{1-\frac{1}{m}\sum_{i=1}^{m}\frac{s_i^-}{x_{i0}}}{1+\frac{1}{q1+q2}\left[\sum_{r=1}^{q1}\frac{s_r^g}{y_{r0}^g}+\sum_{r=1}^{q2}\frac{s_r^b}{y_{r0}^b}\right]} \geq Y_0 \tag{1}$$

$$\text{s.t.}\begin{cases} x_0 = X\lambda + s^- \\ y_0^g = Y^g\lambda - s^g \\ y_0^b = Y^b\lambda + s^b \\ s^- \geq 0,\ s^g \geq 0,\ s^b \geq 0,\ \lambda \geq 0 \end{cases} \tag{2}$$

s^-、s^g、s^b,These indicators represent the amount of slack in inputs、 desired outputs and undesired outputs. While $0 < \rho^* \leq 1$, $\rho^* = 1$, $s^- = 0$, $s^g = 0$, $s^b = 0$, In this case the computation is efficient. Add constraints to the formula as follows:$\sum_{j=1}^{n}\lambda_j = 1$, the variable returns to scale BBC model. Similarly, the scale efficiency calculation formula is as follows:

$$SE = \frac{\rho^{CCR}}{\rho^{BBC}} \tag{3}$$

In addition, in the case of considering undesired output, the Malmquist-Luenberger index is generally used to measure total factor productivity.

This paper adopts the SBM directional distance function based on non-radial angle, which takes into account the reduction of input, undesired output and the increase of desired output. On the basis of the above formula, the SBM directional distance function including the expected output and the undesired output is as follows:

$$\vec{S}_C^t(x_k^t, g_k^t, b_k^t) = \rho^* = \min \frac{1-[\frac{1}{N}\sum_{n=1}^{N} s_n^x/x_n^k]}{1+\frac{1}{M+I}\left[\sum_{m=1}^{M} s_m^g/y_m^k+\sum_{i=1}^{I} s_i^b/b_i^k\right]} \quad (4)$$

$$\text{s.t.}\begin{cases} \sum_{k=1}^{K} \lambda_k^t x_{kn}^t + s_n^x = x_{kn}^t, \ \forall m \\ \sum_{k=1}^{K} \lambda_k^t y_{km}^t - s_m^g = y_{km}^t \\ \sum_{k=1}^{K} \lambda_k^t b_{ki}^t + s_i^b = b_{ki}^t \\ s_n^x \geq 0, \ s_m^g \geq 0, \ s_i^b \geq 0, \ \lambda_k^t \geq 0 \end{cases} \quad (5)$$

$\vec{S}_C^t$ is the directional distance function under the condition of constant returns to scale.s_n^x、s_i^b、s_m^g is the slack of input and output, which respectively represents input, undesired output redundancy and expected output deficiency.$\rho^* = 1$, $s_n^x = s_i^b = s_m^g = 0$, it shows that there is no redundancy of input and undesired output, and lack of expected output, so the decision-making unit is efficient; $\rho^* < 1$, indicates that there is a loss of efficiency.Based on the SBM directional distance function, the Malmquist-Luenberger exponent from period t to period t+1 is constructed as:

$$ML(x^{t+1}, g^{t+1}, b^{t+1}; x^t, g^t, b^t) = \left(\frac{\vec{S}_C^t(x^{t+1},g^{t+1},b^{t+1})}{\vec{S}_C^t(x^t,g^t,b^t)} \times \frac{\vec{S}_C^{t+1}(x^{t+1},g^{t+1},b^{t+1})}{\vec{S}_C^{t+1}(x^t,g^t,b^t)}\right)^{1/2}$$
$$= \frac{\vec{S}_C^{t+1}(x^{t+1},g^{t+1},b^{t+1})}{\vec{S}_C^t(x^t,g^t,b^t)} \times \left(\frac{\vec{S}_C^t(x^{t+1},g^{t+1},b^{t+1})}{\vec{S}_C^{t+1}(x^{t+1},g^{t+1},b^{t+1})} \times \frac{\vec{S}_C^t(x^t,g^t,b^t)}{\vec{S}_C^{t+1}(x^t,g^t,b^t)}\right)^{1/2}$$
$$= TEC(x^{t+1}, g^{t+1}, b^{t+1}; x^t, g^t, b^t) \times EFF(x^{t+1}, g^{t+1}, b^{t+1}; x^t, g^t, b^t) \quad (6)$$

EC and EFF represent the changes in technological progress and green technology efficiency from t to t+1.If the calculated ML index、TEC and EFF are greater than 1, they represent the growth of green total factor productivity、 technological progress and technological efficiency from t to t+1, respectively.

3.2. Data Sources

3.2.1. Selection of input-output indicators

Industrial development requires comprehensive input and interaction of multiple production factors. This research regards the industrial development process as a multi-input multi-output system. It is expected to achieve a higher expected output of industrial economic benefit growth with a lower factor input level. According to the Douglas production function, capital, labor, technology and economic output are the basic variables. Economist Weizmann believes that the sources of economic growth mainly include human capital, physical capital, natural capital and environmental capital. Considering the reduction of energy consumption advocated by green industry, this paper chooses to incorporate resources and environment into the analytical framework of industrial economic growth. Take capital, labor and natural resources as input indicators. take industrial output value and pollution emissions as output indicators.

Regarding the selection of input indicators. The industrial sector mainly includes extractive industries, manufacturing, production and supply of electricity, gas and water. Due to the inability to obtain the statistics of industrial employees at the city level, we chose to use the sum of employees in extractive industries, manufacturing, electricity, gas, and water and electricity supply to measure industrial labor input. About capital factor input. The input of capital factors is measured by the total fixed assets of industrial enterprises above designated size. Input of natural resource factors, Duing to the lack of access to the total energy consumption of industry, measured by the sum of industrial electricity consumption and industrial water consumption. Because energy consumption and water consumption in industrial production are the main sources of undesired output and there is a positive correlation between industrial electricity consumption and industrial added value.[10]Regarding the selection of output indicators, Since the total output value data of industrial enterprises above designated size in 2017 cannot be obtained, the expected output is measured by the total profit of industrial enterprises above designated size. In the selection of undesired output indicators, in order to reflect the environmental pollution caused by industrial activities, industrial smoke、、industrial sulfur dioxide and industrial wastewater emissions are used as undesired output indicators.

3.2.2. Selection of input-output indicators

Considering the availability of data and the representativeness of the samples, 12 major cities in Hubei Province were selected, including Wuhan, Huangshi, Shiyan, Yichang, Xiangyang, Ezhou, Jingmen, Xiaogan, Jingzhou, Huanggang City, Xianning City and Suizhou City.This paper mainly compares and analyzes the data of 12 major prefecture-level cities from 2009 to 2019.The data sources mainly include the 《Statistical Yearbook of Chinese Cities》 and 《Statistical Yearbook of Hubei Province》 over the years.

4.Efficiency measurement and result analysis of industrial green transformation in major cities in Hubei Province

4.1. Efficiency Measurement Based on Super-SBM Model

TABLE 1. CALCULATION TABLE OF INDUSTRIAL GREEN TRANSFORMATION EFFICIENCY OF MAJOR CITIES IN HUBEI PROVINCE FROM 2009 TO 2014

Table	2009	2010	2011	201	2013	2014

Head				2		
Wuhan	0.466	0.420	0.491	0.595	0.662	0.670
Huangshi	0.306	0.371	0.475	0.476	0.496	0.495
Shiyan	0.256	0.285	0.388	0.361	0.355	0.327
Yichang	0.339	0.309	0.315	0.328	0.413	0.469
Xiangyang	0.308	0.568	0.582	0.560	0.567	0.735
Ezhou	0.303	0.305	0.386	0.351	0.358	0.422
Jinmen	0.261	0.355	0.345	0.218	0.301	0.380
Xiaogan	0.237	0.248	0.280	0.341	0.349	0.394
Jinzhou	0.246	0.319	0.238	0.247	0.272	0.335
Huanggang	0.239	0.248	0.257	0.296	0.311	0.345
Xianning	0.331	0.256	0.304	0.302	0.364	0.338
Suizhou	0.390	0.387	0.416	0.309	0.387	0.413

TABLE 2. CALCULATION TABLE OF INDUSTRIAL GREEN TRANSFORMATION EFFICIENCY OF MAJOR CITIES IN HUBEI PROVINCE FROM 2014 TO 2019

Table Head	2015	2016	2017	2018	2019
Wuhan	0.660	0.526	0.684	0.699	0.757
Huangshi	0.542	0.530	0.544	0.627	0.673
Shiyan	0.348	0.323	0.400	0.406	0.527
Yichang	0.406	0.429	0.501	0.567	0.538
Xiangyang	0.580	0.576	0.594	0.635	0.641
Ezhou	0.353	0.363	0.426	0.393	0.369
Jinmen	0.339	0.404	0.382	0.390	0.389
Xiaogan	0.470	0.489	0.433	0.450	0.465
Jinzhou	0.459	0.409	0.496	0.481	0.452
Huanggang	0.337	0.348	0.373	0.386	0.395
Xianning	0.388	0.425	0.399	0.394	0.362
Suizhou	0.389	0.401	0.382	0.464	0.454

As shown in Table, the average industrial green transformation efficiency of major cities in Hubei Province is 0.416, which the overall level is relatively low. It shows that the resource utilization efficiency of industrial development in Hubei Province is not high. The energy consumption of industrial production is high and the situation of industrial pollution discharge is still serious. In the context of green development, Hubei Province has a significant demand for industrial green transformation. From the perspective of the time change trend, the efficiency value fluctuates greatly, but it still shows an upward trend as a whole. From 2009 to 2019, the efficiency of industrial green transformation has improved significantly. Among them, from 2009 to 2015, the efficiency value of industrial green transformation rose slightly in the oscillation. Most cities reached the first peak in 2014 or 2015, and then showed a short decline in 2016.From 2016 to 2019, it showed a more obvious growth trend. It may be that industrial enterprises have been trying to explore effective ways to save energy and reduce emissions. Under the guidance of cost saving and environmental protection goals, after a period of development, they have achieved some results, but they have also entered a bottleneck period of efficiency improvement. With the first proposal of the concept of green development in October 2015, the country has elevated green development to a strategic level. In the context of policy support and increased awareness of low-carbon, industrial enterprises have entered a stage of efficiency improvement through short-term adjustments. The rate of efficiency improvement is faster than the previous stage.

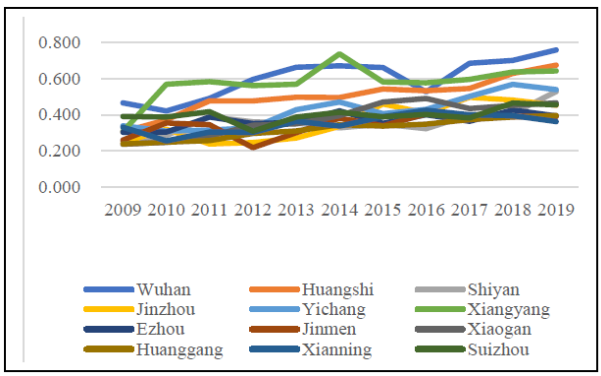

Figure 1. Trend chart of industrial green transformation efficiency value of major cities in Hubei Province from 2009 to 2019

From the perspective of the average industrial green transformation efficiency of major cities in Hubei Province, from high to low, they are Wuhan、 Xiangyang、Huangshi、 Yichang、 Suizhou、 Xiaogan、 Ezhou、 Shiyan、 Jingzhou、 Jingmen、 Xianning Cities and Huanggang City. The corresponding means of these cities are 0.603, 0.503, 0.362, 0.359, 0.421, 0.577, 0.369, 0.342, 0.378, 0.321, 0.351 and 0.399.The efficiency values of Wuhan, Xiangyang, Huangshi and Yichang are at the forefront of the province and the overall industrial green transformation has achieved remarkable results. As the

capital of Hubei Province, Wuhan City has a large industrial scale and a heavy transformation task. However, the optimization of industrial institutions in Wuhan started early and made great efforts. It is transforming from an industrial structure dominated by manufacturing to an industrial structure dominated by modern service industry, which is conducive to a qualitative leap in industrial green development. In addition, Wuhan City has outstanding regional advantages and agglomeration of high-tech enterprises, which is conducive to the development of new technologies and new equipment with green features such as low energy consumption and low emissions. The policy of Wuhan City is first and foremost, which is conducive to the technological transformation and efficiency improvement of existing traditional industrial enterprises. Xiangyang City and Yichang City are second only to Wuhan City in terms of industrial economic scale in the province, which have formed relatively mature industrial enterprise clusters. They are more susceptible to the spillover effects of new technologies in the industrial chain synergy system, which have more advantages in improving the green development efficiency of industrial enterprises. In addition, as a typical resource-declining city, Huangshi City ranks at the forefront in terms of the efficiency value of industrial green transformation. It may be due to the dual pressures of resource depletion and ecological environment that Huangshi City faces, resulting in an urgent industrial green transformation. Huangshi City has strong policy support and clear thinking in terms of industrial green transformation. It has paid close attention to the continuous growth of alternative industries, which has enabled the rapid development of non-industrial industries and the gradual optimization of the industrial structure. The transformation of Huangshi City has progressed rapidly and achieved good results, forming the "Yellowstone Model" of green industrial transformation of resource-based cities, with obvious late-mover advantages. Other major cities are limited by the expansion of industrial volume and the slower growth of input of production factors, resulting in slow update of green technology and equipment. In addition, institutional problems accumulated over a long period of time have also led to a decline in returns to scale, making urban industrial green transformation less efficient.

4.2. Analysis of industrial green total factor productivity results based on GML index

Based on the calculation of the industrial green transformation efficiency of major cities in Hubei Province, we further calculated the industrial green ML index of these cities from 2009 to 2019.

Through the GML index, the evolution law of industrial green transformation can be dynamically analyzed. It can also distinguish whether the promotion of industrial green total factor productivity comes from the improvement of technical efficiency of enterprises or the promotion of technological progress.

TABLE 3. THE AVERAGE VALUE OF INDUSTRIAL GREEN TOTAL FACTOR PRODUCTIVITY AND ITS COMPONENT IN MAJOR CITIES IN HUBEI PROVINCE FROM 2009 TO 2019

Table Head	Wuhan	Huangshi	Shiyan	Yichang	Xiangyang	Ezhou
GTFP	1.075	1.062	0.429	1.024	1.039	1.081
GEC	1.024	1.040	0.958	1.037	1.055	1.059
GTC	0.708	0.680	0.448	0.689	0.664	0.760

TABLE 4. THE AVERAGE VALUE OF INDUSTRIAL GREEN TOTAL FACTOR PRODUCTIVITY AND ITS COMPONENT IN MAJOR CITIES IN HUBEI PROVINCE FROM 2009 TO 2019

Table Head	Jingmen	Xiaogan	Jingzhou	Huanggang	Xianning	Suizhou
GTFP	0.277	0.970	0.667	0.699	0.496	1.027
GEC	0.530	0.974	0.967	0.779	0.980	1.026
GTC	0.641	0.965	0.670	0.684	0.505	0.642

as table，The average value of industrial green total factor productivity in Wuhan, Huangshi, Yichang, Xiangyang, Ezhou and Suizhou cities are greater than 1.It shows that during this period, these cities achieved industrial green total factor productivity growth, with an average growth rate of 5.13%, which industrial growth and resource environment optimization tended to develop in harmony. The average value of industrial green total factor productivity in other cities is less than 1, indicating that the industrial green total factor productivity is declining, which still have the contradiction between industrial growth and resources and environment. From the decomposition of green total factor productivity of industry, its improvement all comes from technical efficiency. The average annual growth rate of technical efficiency in the above six cities is 4.01%.It reflects the positive efforts made by these cities in institutional innovation, experience accumulation, and economies of scale in industrial production.The improvement of green technology progress is not obvious, which may be mainly due to insufficient innovation in production technology and process.

5.Analysis of Influencing Factors of Industrial Green Transformation in Major Cities of Hubei Province

5.1. Model building

Exploring the factors that affect the efficiency of green transformation of the industry is helpful to find a guiding path to improve the effectiveness of the transformation. Due to many influencing factors, scholars generally analyze and study from the aspects of industrial scale, factor endowment, innovation level, government

behavior, environmental regulation, education level, infrastructure, FDI and trade openness. Based on the literature experience and considering the availability of data, this paper constructs the following analysis model:

$$\ln Y = \alpha + \beta_1 \ln GDP + \beta_2 \ln INS + \beta_3 \ln GI + \beta_4 \ln ER + \beta_5 \ln EDU + \beta_6 \ln TI + \beta_7 \ln FDI + \varepsilon_i \quad (7)$$

The super-efficiency value of industrial green transformation in major cities in Hubei Province is selected as the explained variable. Explanatory variables include: The level of economic development (RGDP), this paper takes GDP per capita as proxy variable. Because with the higher level of regional economic development, residents have higher requirements for environmental quality, which is more conducive to promoting the green transformation and development of local industries ; industrial structural upgrade （INS）,Using the ratio of the tertiary industry to the secondary industry as a proxy variable. governmental support(GI),Use local budget revenue to represent government support. The better the local fiscal revenue, the less dependence on tax revenue from high-energy-consumption and high-polluting enterprises. Then the government will be more able to support the industrial sector to adopt clean technology to promote the development of industrial green transformation ; environmental regulation（ER）,Using the comprehensive index of environmental pollution to measure. The higher the comprehensive index of environmental pollution, the weaker the environmental regulation. Education level （EDU） ,Using education expenditure as a proxy variable. Increasing investment in education is conducive to improving the level of local human capital; research investment（TI）, Using scientific expenditure as a proxy variable in the general budgetary expenditure of local finance. Increasing investment in scientific research will help local enterprises to carry out technological innovation, promote the application of new technologies in industrial enterprises, improve the technical efficiency of enterprises, which ultimately promote resource conservation and pollution reduction; foreign direct investment（FDI）,Verifying whether the current FDI has a "pollution paradise effect" or a "pollution halo effect" on industries in major cities in Hubei Province.

5.2. Analysis of Influencing Factors

According to the constructed influencing factor model, the panel regression method is used to carry out the measurement test.Since the industrial green transformation efficiency of Wuhan, Huangshi, Yichang and Xiangyang citiees are more significant than other cities, the analysis of influencing factors is more representative.Therefore, empirical tests were conducted on all major cities in Hubei Province, as well as Wuhan, Huangshi, Yichang, and Xiangyang cities. The Hausman test results of all cities show that the null hypothesis is accepted, so the fixed effect model, random effect model, fixed effect model and random effect model are used respectively. The measurement results are shown in TableV:

As can be seen from Table 3, for major cities in Hubei Province, the level of economic development, government support and the improvement of education level have a significant role in promoting the development of industrial green transformation. The environmental pollution index has a negative relationship with green transformation efficiency, indicating that the weakening of environmental regulation is not conducive to the improvement of industrial green transformation efficiency. It can be seen that the development of the economy, the improvement of public awareness of environmental protection, the improvement of education level, the gathering of high-quality labor force, the sound and perfect environmental management system, the rational application of various environmental policies, the scientific guidance of the government are all green transformation of urban industries. important driving force for development. The role of foreign direct investment in promoting the efficiency of urban industrial green transformation is weak. Due to the high proportion of state-owned enterprises in large-scale industries in cities, the obvious institutional constraints in inland areas, the overall level of foreign direct investment is relatively low, resulting in less impact from it. The upgrading of the industrial structure is not conducive to the improvement of the efficiency of industrial green transformation, but its role is very weak.It may be that most of the industrial enterprises belong to the heavy industry and lack the impact of technological improvement brought about by the development of the tertiary industry, resulting in the crowding out of resources such as talents and capital. The coefficient of scientific expenditure on the efficiency of industrial green transformation is positive but not significant, indicating that there is currently a problem of low efficiency of scientific and technological input and output. Government R&D support has not had the desired effect in driving technological progress.

TABLE 5. REGRESSION ANALYSIS OF INFLUENCING FACTORS OF INDUSTRIAL GREEN TRANSFORMATION EFFICIENCY IN MAJOR CITIES IN HUBEI PROVINCE

Explaining variable	All the city	Wuhan	Yichang	Huangshi	Xiang yang
ln RGDP	0.2406*** (3.82)	0.8331*** (3.52)	-0.0221 (-0.31)	-0.3112** (-2.05)	0.4132*** (5.01)

ln INS	-0.1005*	-1.3479***	-0.1952**	-0.4001***	0.1321
	(-1.09)	(-6.28)	(-1.04)	(-4.76)	(0.91)
lnGI	0.3674***	1.0226***	0.5012***	-0.1470	0.6705***
	(4.13)	(3.05)	(3.46)	(-2.08)	(3.88)
ln ER	-0.2247***	-0.6496***	-0.2331***	-0.4102***	-0.0217
	(-7.88)	(-5.31)	(-5.48)	(-6.25)	(-0.38)
ln EDU	0.5800***	0.3226	0.2244**	0.3777***	1.8009***
	(6.98)	(1.02)	(1.98)	(3.72)	(5.84)
ln TI	0.0701	-0.1377	0.1770**	0.0051	-0.1421
	(1.13)	(-0.54)	(2.32)	(0.13)	(-1.66)
lnFDI	0.0266**	0.1321**	0.0176	0.1379***	-0.0559
	(2.05)	(2.05)	(1.21)	(6.88)	(-1.60)
Constant term	-1.3446***	-1.3208***	0.3210	-0.4332	-1.0021
	(-2.17)	(-5.86)	(0.65)	(-0.94)	(-0.51)
R2	0.8775	0.6609	0.8720	0.6250	0.721

Note: *,**, *** represent the 10%, 5% and 1% significance levels. The z-values are in parentheses.

From the analysis results of Wuhan City, economic development, government support, environmental regulation, education level and foreign investment constitute important driving forces for its industrial green transformation and development. The optimization and upgrading of the industrial structure has an inhibitory effect on the green transformation of the industry. The efficiency coefficient of scientific expenditure and industrial green transformation is negative but not significant; Judging from the analysis results of Yichang City, government support, environmental regulation, education level improvement and scientific expenditure constitute important driving forces for the green development of its industry. The coefficient of economic development level is negative but not significant.It is possible that Yichang's economic growth mode has always been characterized by extensive features, resulting in economic growth having a certain inhibitory effect on the improvement of the efficiency of industrial green transformation. However, with the transformation of the economic development mode, the inhibitory effect on the development of industrial green transformation is becoming weaker and weaker. The upgrading of industrial structure has an inhibitory effect on the development of industrial green transformation. The coefficient of foreign direct investment is positive but not significant; From the analysis results of Huangshi City, the improvement of education level, environmental regulation and foreign direct investment have obvious promoting effects on the efficiency of industrial green transformation. However, economic development and industrial structure upgrading have obvious inhibitory effects on the efficiency of industrial green transformation. The coefficient of government support is negative but not significant, the possible reason is that resource-declining cities shrink sharply with the depletion of resources. After years of resource exploitation, not only is the environmental pollution problem serious, the backward system and the business environment lacking comparative advantages have all led to huge difficulties in transformation and development. Under the pressure of developing the economy and increasing taxes, the local government may continue to use the extensive development model. The coefficient of science spending is positive but not significant; From the analysis results of Xiangyang City, the economic development, the improvement of education level and government support have obvious promoting effects on its industrial green transformation and development. The coefficient of industrial structure upgrading is positive but not significant, indicating that industrial structure upgrading has a certain role in promoting transformation, but this role is weakening. Environmental regulation has a weak and insignificant effect on industrial green transformation. The coefficients of scientific expenditure and foreign investment are negative and not significant.

6.Conclusions

This paper uses panel data from 2009 to 2019 to calculate the industrial green transformation efficiency and green total factor productivity of major cities in Hubei Province. It is found that the efficiency of industrial green transformation is low but has an overall improvement trend, showing an upward trend of oscillating fluctuations. Among them, the average efficiency of Wuhan, Xiangyang, Huangshi, Yichang and Suizhou cities rank in the forefront. The industrial green total factor productivity shows the characteristics of urban differences. Among them, Wuhan, Xiangyang, Huangshi, Yichang, Suizhou and Ezhou cities have achieved growth in industrial green total factor productivity. This growth is all due to improvements in technical efficiency. The role of technological progress is not reflected. Judging from the factors affecting the efficiency of industrial green transformation in major cities in Hubei Province, the level of economic development, government support, improved education, and environmental regulation have obvious promoting effects, which are important driving forces for the development of urban industrial green transformation. The role of foreign direct investment in promoting the

efficiency of urban industrial green transformation is weak. The upgrading of the industrial structure has a weak inhibitory effect on the green transformation of the industry. Government R&D support has not played a significant role in the green transformation of urban industries. Economic development, government support, environmental regulation, education level and foreign investment constitute important driving forces for the green transformation and development of urban industries in Wuhan; Government support, environmental regulation, improvement of education level and scientific expenditure are important driving forces for the green transformation and development of Yichang's urban industry; The improvement of education level, environmental regulation and foreign direct investment have obvious promotion effects on the efficiency of urban industrial green transformation in Huangshi City. Economic development, education level improvement and government support have significantly promoted the green transformation and development of Xiangyang's urban industry.

According to the conclusion of the study, the extensive characteristics of traditional industries in Hubei Province still exist. The government should increase the financial and policy support for industrial green transformation, while optimizing the management system and production process of enterprises. Under the goal of energy conservation and emission reduction, guide enterprises to focus on reducing energy consumption in production and reducing industrial waste emissions; For emerging industries, the government should increase environmental management efforts. Forcing enterprises to pay attention to the research and application of green new technologies and new processes. Improve the quality and speed of technological progress; In view of the differences in the effectiveness of industrial green transformation between cities, measures should be taken according to local conditions. Reasonable layout of urban industrial development, along with optimization of industrial coordination system. By increasing the scientific and technological investment of local finance, the technology spillover effect of high-tech enterprises will be fully stimulated. The regional innovation level will be improved; In addition, the policy support system for industrial green transformation should be gradually improved to give full play to the guiding role of the government. Encourage and drive enterprises to practice the strategic goal of industrial green transformation.

ACKNOWLEDGMENT

This research is supported by the 2021 annual scientific research project of the Hubei Provincial Department of Education. The number of the fund project is B2021494.

REFERENCES

[1] Wang YUN,Sun Xiaohua. (2017) The mechanism of government subsidies driving industrial transformation and upgrading. China's industrial economy., 10: 99–117.

[2] Kou Huanhuan. (2019) Evaluation of high-quality development level of industrial economy in Hubei Province. Hubei Academy of Social Sciences.

[3] Ye Xueping,Sun Lijun. (2017) Transformation and upgrading and independent innovation of Hubei industry in the new stage.Hubei Social Sciences., 02: 57–62.

[4] Li Ming. (2015) Research on the effect of industrial transformation and upgrading in resource-exhausted cities in Hubei Province.Wuhan Institute of Technology.

[5] Liu Xiping,Guan Ke. (2018) Measurement and Evaluation of Green Development Efficiency of Hubei Yangtze River Economic Belt. Statistics and Decision., 34: 103–106.

[6] Yuan Yijun,Xie Ronghui. (2015) FDI 、 Environmental regulation and China's industrial green total factor productivity growth—Empirical Research Based on Luenberger Index. international trade issues.,08:84–93.

[7] Yan Hongping. (2016) Research on China's Industrial Green Total Factor Productivity Growth and Its Convergence—Empirical Analysis Based on GML Index. Journal of Northwestern Polytechnical University (Social Science Edition.,36:44–51.

[8] Chen Yao. (2018) Efficiency evaluation of China's regional industrial green development—Based on R&D input perspective.Economic issues.,12:77–83.

[9] Guo Xiaoming, Huang Sen. (2018) Beautiful China" Research on the impact of China's regional industrial transfer on industrial green efficiency under the background—Based on SBM-undesirable model and spatial econometric model. Journal of Chongqing University(Social Science Edition).,24:1–11.

[10] Guo Ying, Jin Ying. (2010) Analysis of the relationship between industrial electricity consumption and economic growth-An empirical study based on panel data of 11 cities in Zhejiang. Journal of Jiangsu University of Science and Technology (Social Science Edition).,10:50–53.