Research on the Driving Effect of Industrial Ecological Innovation Efficiency in the Information Age

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Abstract：With the "Internet plus", the concept of Industry 4.0, the Internet seems to have become many industrial enterprises in the way of transformation and upgrading of "Life-saving straw". According to the present situation of industrial development in China, a dynamic system of promoting industrial ecological innovation efficiency is constructed, and the influencing factors of industrial ecological innovation efficiency are analyzed by using multiple regression model, it is found that the factor endowment in the basic power has a significant impact on the efficiency of industrial ecological innovation, and the market-oriented reform and technological progress in the power of innovation have a significant impact. It also makes use of the innovation power and the basic power to do the dual regression, which proves that both of them have a significant positive driving effect on the industrial ecological innovation efficiency, and the driving effect of fundamental power on the efficiency of industrial ecological innovation is slightly stronger than that of innovation power.

1 Introduction

In the Information Age, China's industry is developing rapidly. However, China's industry is facing outstanding problems and challenges. A large number of industrial pollution and resource consumption have caused unprecedented damage to the ecological environment. At the 19th Party Congress, General Secretary Xi Jinping pointed out that the driving force of economic development is shifting from factor-driven to innovation-driven, showing that sustainable economic development is the path of developing ecological innovation. The industrial eco-innovation efficiency, which aims at promoting the sustainable development of environment, economy and society, is a new driving force system of eco-innovation. Therefore, it is necessary to explore which factors have a specific effect on the efficiency of industrial eco-innovation, and to explore the power system and the final driving effect of industrial eco-innovation efficiency.

In national and international scientific research, the efficiency of industrial ecological innovation is increasingly becoming a research hotspot. As for the definition of industrial eco-innovation, Fussler & James first proposed Green Innovation in 1996, and the following year James defined it explicitly as "New products and processes that significantly reduce environmental impacts and add value to customers and enterprises"[1]. Han jieping holds that industrial ecological innovation is a process, technology, operation, system and product innovation, which should consider economic, social and environmental benefits[2]. Fan Decheng argues that there are similarities and differences among the driving forces of industrial eco-innovation in different regions[3]. In the aspect of influencing factors of industrial eco-innovation efficiency dynamic system, Han jieping thinks that the development of industrial eco-innovation efficiency should be analyzed from MACRO, Meso and micro levels[4]. Hui Shupeng and others think that the innovation power is the key power of the industrial ecology innovation efficiency growth[5]. Generally speaking, researchers at home and abroad are at the initial stage of studying industrial ecological innovation, and have not yet established a sound evaluation index system of industrial ecological innovation efficiency, there are few studies on the dynamic system and driving effect which affect the efficiency of industrial eco-innovation.

2 Construction of dynamic system of industrial ecological innovation efficiency

2.1 Data source

The original data are from the 2014-2018 China Statistical Yearbook, China Industrial Statistical Yearbook, China Energy Statistical Yearbook and the Blue Book of the report on the integrated development of China's informatization and industrialization.

2.2 Dynamic index system

Considering the availability of data, the impact factors

are summarized into two types, the first type is the basic factor of industrial development, reflecting the current situation of industrial development, environment and input, and the second type is the innovation factor of industrial transformation, system Innovation, technology innovation and all kinds of innovation factors of information technology influencing industrial development in the new era.

Table 1 power system of industrial ecological innovation efficiency

Dynamic system	
Foundation power BSP	Scale of industrial development IDS Degree of openness FCD Factor Endowment FEN Energy consumption structure ECS
Innovation Drive IND	Environmental Regulation ENR Technological progress TEP Market reform MOR Technological Convergence TEI

3 Study on the driving effect of industrial ecological innovation efficiency

3.1 regression modeling

The basic factors and innovation factors are selected to make a statistical regression model about the innovation efficiency of industrial ecology. The regression model is as follows:

$$Y = a_0 + a_1 \ln X_1 + a_2 \ln X_2 + a_3 \ln X_3 + a_4 \ln X_4 + a_5 \ln X_5 + a_6 \ln X_6 + a_7 \ln X_7 + a_8 \ln X_8 + e \quad （1）$$

Among them: Y is the dependent variable of industrial ecological innovation efficiency, XI (i = 1,2,3...) is the independent variable, X 1: Industrial Development Scale (IDS) , x 2: Factor Endowment (Fen) , X 3: openness to the outside world (FCD) , X 4: energy consumption structure (ECS) , X 5: Environmental Regulation (ENR) , X 6: Market Oriented Reform (Mor) , x 7 is the technical progress (Tep) , X 8 is the technical fusion (Tei) , (i = 1,2,3...) is the coefficient of the independent variable, is the constant term, e is the random error.

So the regression model is:

$$Y = 0.1221 \ln X_1 + 0.1541 \ln X_2 + 0.0145 \ln X_3 - 0.0216 \ln X_4 - 0.0181 \ln X_5 - 0.7028 \ln X_6 + 0.6262 \ln X_7 - 0.0614 \ln X_8 + 1.37152 \quad （2）$$

Table 2 statistical regression model of influencing factors of industrial eco-innovation efficiency

	Mixed effect model ln_tfpch	Random effects model ln_tfpch	Fixed-effect model ln_tfpch
ln_ids	0.0944	0.0889	0.1221
	（1.44）	（1.01）	（0.87）
ln_fen	0.0245	0.0753**	0.1541***
	（0.81）	（2.23）	（3.56）
ln_fcd	0.1044***	0.1417***	0.0145
	（3.91）	（3.91）	（0.17）
ln_ecs	0.0479	-0.007	-0.0216
	（1.28）	（-0.21）	（-0.58）
ln_enr	-0.0419	-0.0313	-0.0181
	（-1.52）	（-1.34）	（-0.78）
ln_mor	-0.6311***	-0.4889***	-0.7028**
	（-5.55）	（-3.17）	（-2.56）
ln_tep	0.7209***	0.6145***	0.6262***
	（7.34）	（8.91）	（9.29）
ln_tei	0.2373**	0.0517	-0.0614
	（2.38）	（0.49）	（-0.45）
_cons	0.476	0.903**	1.3715***
	（1.18）	（2.16）	（2.77）
N	150	150	150
Adj.R^2	0.395	0.4744	0.52

Based on the statistical regression analysis of the above eight influencing factors, we can classify these eight factors into two kinds of driving forces, one is the basic power (BSP) , which includes the industrial ecological scale, factor endowment, the degree of opening to the outside world and the energy consumption structure, the other is the innovation impetus (Ind) , including environmental regulation, market-oriented reform, technology progress and technology integration. By classifying every four factors into a class of driving forces, we make a binary statistical regression model, which is as follows:

$$Y = b_0 + b_1 \ln Z_1 + b_2 \ln Z_2 \quad （3）$$

Among them, y is the dependent variable of industrial ecological innovation efficiency, BI (i = 1,2,3...) is the independent variable coefficient, Zi (i = 1,2,3...) is the independent variable, BSP and Ind..

Through STATA13.1 software, the statistical regression model of industrial eco-innovation efficiency dynamic system is as follows:

Table 3 regression model of industrial ecological innovation efficiency dynamic system

	Mixed effect model ln_tfpch	Random effects model ln_tfpch	Fixed-effect model ln_tfpch
ln_bsp	-0.1728	0.531**	1.3571***
	（-0.69）	（2.03）	（4.64）
ln_ind	0.5054***	0.9289***	1.2089***
	（3.97）	（8.09）	（10.2）
_cons	0.2754	-0.6971	-1.879***
	（0.71）	（-1.75）	（-4.3）
N	150	150	150
Adj.R2	0.114	0.4881	0.5089

So the regression model is:

$$Y = -1.879 + 1.3571\ln Z_1 + 1.2089\ln Z_2 \quad （4）$$

3.2 analysis of regression results

Among the basic factors, factor endowments have a significant positive impact on the efficiency of industrial ecological innovation, indicating that the improvement of industrial ecological innovation efficiency is still inseparable from fixed asset investment and personnel labor to a certain extent. The degree of opening to the outside world has a positive impact on the efficiency of industrial ecological innovation, which shows that the total industrial import and export volume and local GDP are the factors that affect the efficiency of industrial ecological innovation. The scale of industrial development has a positive impact on the efficiency of industrial ecological innovation, indicating that the development of my country's industry is steadily improving. The impact of energy consumption structure on the efficiency of industrial ecological innovation is negatively correlated. As a non-renewable energy source, excessive consumption of coal will directly affect the improvement of industrial ecological efficiency.

Among the innovation factors, market-oriented reforms and technological progress have a significant negative impact on the efficiency of industrial ecological innovation, indicating that market-oriented reforms will hinder the improvement of industrial ecological innovation efficiency. Technological progress has a significant negative impact on the efficiency of industrial ecological innovation, indicating that the index system that affects the efficiency of industrial ecological innovation will hinder the improvement of industrial ecological innovation efficiency. Technology integration has a positive impact on the efficiency of industrial ecological innovation, indicating that the integrated development of my country's industry and information technology will actively promote the improvement of industrial ecological innovation efficiency. Environmental regulations also have an impact on the efficiency of industrial ecological innovation, indicating that the efficiency of industrial ecological innovation in my country will be affected by many aspects and fields.

4 Conclusion

This paper firstly constructs a regression model of industrial ecological innovation efficiency by constructing a statistical regression model of the influencing factors of industrial ecological innovation efficiency, dividing basic power and innovation power into four types of influencing factors, and constructing a regression model of industrial ecological innovation efficiency. On the basis of the preliminary multiple regression model, the factors that have positive effects include industrial ecological scale, factor markets, degree of opening to the outside world, and technological progress. Factors that have negative effects include energy consumption structure, environmental regulations, market reforms, and Technology integration. Secondly, by constructing a statistical regression model of the driving forces of industrial ecological innovation efficiency.The results show that the driving effect of basic power is slightly stronger than that of innovation power.Moreover, basic power and innovation power have a significant positive impact on the driving force of industrial ecological innovation efficiency. The driving role is gradually strengthening.It can be seen from the statistical regression model that it seems that as long as the investment in basic power is increased, the efficiency of industrial ecological innovation can be improved.But this is not the case,The driving effect of innovation power on the efficiency of industrial ecological innovation may show a nonlinear effect with some control variables.Breaking the constraints of the environment and resources and striving to achieve the sustainable development of the industry must do everything possible to improve the efficiency of industrial ecological innovation.

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