Research on the green transition of heavy chemical enterprises in Jiangsu Province

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Abstract. By carrying out the green transition and upgrading of heavy chemical industry in Jiangsu, it is conducive to improving the industrial competitiveness and the level of clean production of key industries; it is conducive to establishing the system and mechanism of ecological priority and green development of the Yangtze River economic belt, and promoting high-quality development. Based on the development practice of heavy chemical industry in Jiangsu Province, this study analyzes its negative effects on the high-quality development of the Yangtze River economic belt. This paper puts forward the index of green transition of industry, establishes the measurement and evaluation model of green transition of heavy chemical industry in Jiangsu Province. Based on the empirical research results, this paper puts forward the green transition path of Jiangsu heavy chemical industry.

1. Introduction

Since the development of the Yangtze River economic belt has been established as a national major regional development strategy, relevant departments of the central government and 11 provinces and cities in the Yangtze River Basin have formulated planning policy systems, established institutional mechanisms and promoted the implementation of policies. The high-quality development of the Yangtze River economic belt has made a good start, but there are still many difficulties and challenges. The main points are: the high-density layout of heavy chemical industry along the river, the hidden danger of environmental pollution still exist, the concept of ecological priority and green development is not fully implemented; the traditional extensive development mode is still dominant, and the green development of new technology, new formats, new models and new industries is still insufficient. Jiangsu, as the leader of the Yangtze River economic belt, has a large proportion of the total economic volume in 11 provinces and cities (about 27% on average in the past three years), and more emphasis is placed on the industrial structure. There are many heavy chemical enterprises along the Yangtze River in Jiangsu Province. At present, 2 / 3 of the heavy chemical production capacity of the province is concentrated on both sides of the river, and the waste water discharge accounts for 74% of the province. Along the Yangtze River, there are more than 700 chemical enterprises, more than 110 chemical terminals, and an annual transit volume of more than 200 million tons of hazardous chemicals. The "crisscross" of sewage outlets and water intakes has further deteriorated the environmental quality [1-6]. Therefore, it is urgent to find out the base number of heavy chemical
enterprises in Jiangsu Province, implement precise policies, promote the transformation and upgrading of heavy chemical industry in Jiangsu Province, and realize green development. There are few research results on green transition of heavy chemical enterprises in China. Zhao Ao has successively carried out the research on the evaluation system of green transition and innovation development of resource-based cities in Liaoning Province and the research on green transition of northeast old industrial base [7-8]. Mali carried out research on the path of industrial green transition in coastal areas [9]. Zhang Jinhua carried out path analysis of green transition of China's manufacturing industry based on the goal of carbon neutralization [10]. Cui Yixia carried out research on green transition and development of resource exhausted cities in China [11]. Fu Yao studies the green transition of China's iron and steel industry based on the background of environmental regulations [12]. Based on the analysis of the basic concepts and development characteristics of resource-based cities, Xiao Ying studied the industrial green transition of resource-based cities [13]. According to the development status of heavy chemical green transition in Jiangsu Province, this study puts forward the indicators of industrial green transition, establishes the measurement and evaluation model of heavy chemical green transition in Jiangsu Province, and discusses the change mode of industrial transformation. This paper puts forward the green transition path of Jiangsu heavy chemical industry from two aspects of technological innovation and institutional innovation.

2. Analysis on the development of heavy chemical industry in Jiangsu Province

2.1. Analysis on the internal industry structure of heavy chemical industry

In 2017, chemical raw materials, electrical machinery and communication equipment manufacturing industry accounted for the highest proportion in the heavy chemical industry, with a total contribution rate of 38.16%, of which only computer, communication and other electronic equipment manufacturing industry accounted for 14.12%. This shows the rapid development of Jiangsu communication industry. The contribution rate of ferrous metal smelting and rolling processing industry, general equipment manufacturing industry, special equipment manufacturing industry, automobile manufacturing industry, power and heat production and supply industry is between 5% and 10%. The contribution rate of pharmaceutical manufacturing, chemical fiber manufacturing, rubber and plastic products, non-metallic mineral products, non-ferrous metal smelting and rolling processing, metal products, railway, ship, aerospace and other transportation equipment manufacturing, instrument and meter manufacturing, water production and supply industry is between 1% and 5%. The contribution rate of other industries is less than 1%.

2.2. Environmental impact of heavy chemical industry in Jiangsu Province on the Yangtze River Economic Belt

A large amount of waste water, waste gas and solid waste produced by heavy chemical enterprises in Jiangsu Province have negative effects on the environment.

① Industrial wastewater discharge is large, and water pollution of the Yangtze River is becoming more and more serious. Jiangsu, as the leader of the Yangtze River economic belt, has a large proportion of the total economic volume in 11 provinces and cities (about 27% on average in the past three years), and more emphasis is placed on the industrial structure. There are many heavy chemical enterprises along the Yangtze River in Jiangsu Province. At present, 2 / 3 of the heavy chemical production capacity of the province is concentrated on both sides of the river. The wastewater discharge accounts for 74% of the total amount of the province. The water quality of Jiangsu section has been reduced to three categories. Along the Yangtze River, there are more than 700 chemical enterprises, more than 110 chemical terminals, and an annual transit volume of more than 200 million tons of hazardous chemicals. The "crisscross" of sewage outlets and water intakes has further deteriorated the environmental quality.

② Industrial waste gas emission is large, and air pollution of the Yangtze River is increasing. There are many heavy chemical enterprises in Jiangsu section of the Yangtze River. Within a distance
of less than 200 kilometers, more than 100 chemical enterprises are gathered. These chemical enterprises produce a lot of waste gas, such as CO$_2$, SO$_2$, NO$_x$, smoke dust, etc. In recent years, the emission of heavy chemical industry in the Yangtze River economic belt has shown a monotonous growth trend. In 2014, the total emission of exhaust gas reached 5760.703 billion cubic meters, among which, the emission of SO$_2$, NO$_x$, smoke and dust were 664700, 789700 and 596400 tons respectively, and the problem of air pollution has become increasingly serious.

Large amount of industrial solid waste is produced, and the environmental quality of the Yangtze River is deteriorating day by day. For a long time, many heavy chemical enterprises gathered in the Yangtze River economic belt have produced a large number of solid wastes and accumulated in the Yangtze River all the year round. These solid wastes enter the Yangtze River through surface runoff without treatment, and their harmful substances will seriously pollute the water body. In addition, the light substance of solid waste is scattered with the wind, which causes serious pollution to the atmosphere. In recent years, the amount of industrial solid waste along the Yangtze River in Jiangsu Province has been increasing. By 2014, the industrial solid waste production was about 100.5922 million tons.

3. Measurement analysis of green transition of heavy chemical industry in Jiangsu Province

3.1. Measurement model of green transition of heavy chemical industry in Jiangsu Province

The green transition of heavy chemical industry reflects the green development level of such industry. In this study, the measurement of green transition examines the change of pollution emission per unit output value of a heavy chemical industry. The calculation formula is [9]:

$$C_t = \frac{W_t - W_{t0}}{V_t - V_{t0}}$$  \hspace{1cm} (1)

where: $C_t$ is the green transition index of pollutant $i$ in the $t$ period; $W_t$ is the emission of pollutant $i$ in the $t$ period; $V_t$ is the gross output value of heavy chemical industry in the $t$ period; $W_{t0}$ is the emission amount of pollutant $i$ in the research base period (including the emission amount of waste water, exhaust gas and solid waste); $V_{t0}$ is the gross output value of heavy chemical industry in the research base period. When the $C_t$ value is greater than zero, the pollution discharge per unit output value in the $t$ period is greater than that in the base period, indicating that the heavy chemical industry has not realized the green transition; on the contrary, when the $C_t$ value is less than zero, the pollution discharge per unit output value in the $t$ period is less than that in the base period, indicating that the heavy chemical industry has realized the green transition.

Based on the principle of data availability, only three kinds of pollutants are selected in this study, which are industrial wastewater discharge, industrial waste gas discharge and industrial solid waste production. In view of the principle of "short board effect", the overall efficiency transformation coefficient ($C_t$) of a region is defined as the maximum value of the efficiency transformation coefficient of three pollutants, that is, the minimum value of industrial efficiency transformation effect [9]. The formula is:

$$C_t = \max(C_{t\text{water}}, C_{t\text{gas}}, C_{t\text{solid}})$$  \hspace{1cm} (2)

3.2. Green transition measurement of heavy chemical industry in Jiangsu Province

The state has carried out special actions on industrial energy conservation and green development since 2013. Therefore, 2013 is taken as the research base period to study and analyze the green transition and development level of heavy chemical industry in Jiangsu Province in 2014. Relevant data are from Jiangsu statistical yearbook. Use the above green transition measurement methods to calculate the values of $C_{t\text{water}}$, $C_{t\text{gas}}$, $C_{t\text{solid}}$ and $C_t$ respectively, as shown in Table 1.
Table 1. Green transition measurement value of Jiangsu heavy chemical industry in 2014.

| Industry | $C_{\text{water}}$ | $C_{\text{gas}}$ | $C_{\text{solid}}$ | $C_t$  |
|----------|--------------------|------------------|-------------------|-------|
| Coal mining and washing industry | -3.1812 | -0.0148 | -0.1515 | -0.0148 |
| Ferrous metal mining and beneficiation industry | -0.7045 | -0.0051 | -0.2945 | -0.0051 |
| Nonferrous metal mining and processing industry | -0.2359 | 1.9774 | 1.6454 | 1.9774 |
| Nonmetal mining and processing industry | 0.0534 | 0.0016 | 0.0179 | 0.0534 |
| Petroleum processing, coking and nuclear fuel processing industry | -0.4916 | 0.0205 | -0.0008 | 0.0205 |
| Chemical raw materials and chemical products manufacturing industry | -0.4608 | 0.4136 | -0.0061 | 0.4136 |
| Pharmaceutical manufacturing | -0.2518 | 0.0085 | -0.0007 | 0.0085 |
| Chemical fiber manufacturing | -0.1029 | 0.0250 | 0.0044 | 0.0250 |
| Rubber and plastic products industry | -0.1288 | -0.0269 | -0.0004 | -0.0004 |
| Nonmetallic mineral products industry | -0.0747 | -0.1077 | 0.0001 | 0.0001 |
| Ferrous metal smelting and rolling industry | -0.0070 | 0.2257 | 0.0409 | 0.2257 |
| Nonferrous metal smelting and rolling industry | -0.1256 | -0.0088 | -0.0042 | -0.0042 |
| Metal products industry | -0.1232 | 0.0196 | -0.0021 | 0.0196 |
| General equipment manufacturing industry | -0.0410 | -0.0006 | -0.0004 | -0.0006 |
| Special equipment manufacturing industry | -0.0369 | -0.0070 | -0.0006 | -0.006 |
| Automobile manufacturing industry | -0.0196 | 0.0031 | -0.0003 | 0.0031 |
| Manufacturing of railway, ship, aerospace and other transportation equipment | 0.0051 | 0.0023 | 0.0003 | 0.0051 |
| Electrical machinery and equipment manufacturing industry | -0.0211 | 0.0059 | -0.0002 | 0.0059 |
| Manufacturing of computer, communication and other electronic equipment | 0.0009 | 0.0027 | 0.0001 | 0.0027 |
| Instrument manufacturing industry | -0.0077 | 0.0061 | 0.0001 | 0.0061 |
| Production and supply of power and heat | -0.0914 | 0.1407 | -0.0193 | 0.1407 |

It can be seen from Table 1 that the green transition effect of other industries is not ideal except for the coal mining and washing industry, ferrous metal mining industry, rubber and plastic products industry, non-ferrous metal smelting and rolling processing industry, general equipment manufacturing industry, and special equipment manufacturing industry. Among them, the transformation coefficient of mining and beneficiation efficiency of non-ferrous metal mine is the largest, which is 1.9774. It shows that the environmental deterioration of the industry in the research stage is not enough attention, and no effective green development measures are taken to deal with the increasingly serious problems of resources and environment. For such industries, it is necessary to strengthen regional cooperation, develop technological innovation, implement ecological compensation mechanism, implement industrial transfer and other measures to optimize industrial structure and promote green transition of heavy chemical industry.

3.3. Research on the path of green transition of heavy chemical industry in Jiangsu Province

In order to promote the high-quality development of the Yangtze River economic belt, it is necessary to accelerate the green development of enterprises along the river, rationalize and coordinate the relationship between economy, environment, regional competition and other institutional mechanisms. Therefore, we must make great determination to solve the problem of heavy chemical industry pollution in Jiangsu Province, and put forward the green transition path guided by ecological innovation [2, 14-15].

① Strengthen top-level design and scientific planning.
To promote the high-quality development of the Yangtze River economic belt and the green transition of Jiangsu heavy chemical industry, it is necessary to strengthen the top-level design and scientific planning at the national and provincial levels. First, we need to integrate the objectives, measures and projects of ecological protection of the Yangtze River economic belt into the development plan of heavy chemical industry in the region, strictly implement the system of accountability for ecological damage of leading cadres of the party and government, and relevant departments should do a good job of overall coordination, supervision and guidance according to their respective functions. In view of the environmental pollution of heavy chemical industry, joint prevention and treatment measures are taken to build a multi-party consultation mechanism with provinces and cities along the river as the main body, so as to promote the industrial transfer and interactive cooperation between provinces and cities. Second, establish and improve diversified ecological compensation mechanism for heavy chemical industry [16]. Strengthen the collection of garbage and sewage treatment fees; establish a product labeling system to promote green consumption mechanism from the government, enterprises and the public; follow the basic principle of pollution payment, and strengthen the implementation of the paid use system of ecological environment.

② Promote "smart +" strategic emerging industries.

We will encourage the use of high and new technologies to transform and upgrade traditional industries such as heavy chemical industry, and vigorously promote strategic emerging industries with "intelligence +". Accelerate the development of strategic emerging industries, continue to increase the proportion of the tertiary industry, promote the optimization and upgrading of industrial structure, and establish a sound modern industrial system. This strategic choice can not only promote the improvement of technology level and accelerate the industrial upgrading, but also provide a huge national economic demand and market foundation for informatization and ecology.

First, support core technology research and development of advantageous manufacturing industries. For the manufacturing of new energy equipment and power equipment, from the perspective of energy conservation and environmental protection, strengthen the research and development of core key technologies, develop a batch of green products with independent intellectual property rights, high added value and market competitiveness, upgrade from the low end of the industrial chain to the high end of the industrial chain, and from the low end of the value chain to the high end of the value chain, so as to build a green technology system of the manufacturing industry. Second, strengthen product and brand innovation. Focus on market demand, promote secondary innovation of traditional products; focus on innovation and development, improve product R & D level. To guide advantageous enterprises to integrate the production capacity of many unlicensed processing enterprises by means of acquisition, merger, holding and combination. We will guide advantageous enterprises to acquire foreign brands and urge them to strengthen product quality management. Third, we should strengthen basic scientific research on environmental protection, and comprehensively promote technological integration innovation and ecological management innovation such as source control, process reduction, and end-to-end treatment of enterprise production pollution. Relying on low-carbon, recycling, environmental protection and other provincial high-tech industrial development zones, a national eco industrial demonstration park will be established to promote the development of industrial parks in the direction of ecology.

③ Deepen system innovation and implement ecological protection mechanism.

First, we will urge strict implementation of laws and regulations such as the new environmental protection law, the Yangtze River Economic Belt ecological environment protection plan, and the Jiangsu Yangtze River Economic Belt ecological environment protection implementation plan. Second, in accordance with the requirements of the "ecological red line" of the central government, further improve the provincial environmental supervision and accountability mechanism, and increase the efforts of accountability. The third is to establish the compensation mechanism of ecological environment in the Yangtze River Basin Based on the water environment quality. The higher the proportion of water quality reaching the first class water standard, the more rewards will be given; on the contrary, punitive fines will be imposed on the third class, especially the fourth class. The fourth is
to establish an energy-saving trading system guided by GDP energy consumption. By building an energy-saving trading platform, regions with low energy consumption per unit of GDP can sell the corresponding energy-saving.

4. Conclusions
Based on the development practice of heavy chemical industry in Jiangsu Province, this study analyzes its negative effects on the high-quality development of the Yangtze River economic belt. Based on the development state of green transition of heavy chemical industry in Jiangsu Province, this paper puts forward the index of green transition of industry, establishes the measurement and evaluation model of green transition of heavy chemical industry in Jiangsu Province, and discusses the change pattern of industrial transformation. The green transition path of heavy chemical industry in Jiangsu Province is put forward by means of technological innovation and institutional innovation. ① To promote the high-quality development of the Yangtze River economic belt and the green transition of Jiangsu heavy chemical industry, it is necessary to strengthen the top-level design and scientific planning at the national and provincial levels. ② We will encourage the use of high and new technologies to transform and upgrade traditional industries such as heavy chemical industry, and vigorously promote strategic emerging industries with "intelligence +". ③ Deepen system innovation and implement ecological protection mechanism.

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