Analysis of Industrial Economic Growth and Environmental Pollution in Tianjin Based on Tapio Decoupling Model

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Abstract. In order to accelerate the construction of a resource-saving and environmentally-friendly industrial ecosystem, this paper uses the Tapio decoupling analysis model to calculate the decoupling index of Tianjin's industrial economic growth and the major environmental pollutants of the industry from 2005 to 2015 and analyze the decoupling status. The results show that the decoupling state of Tianjin's economic growth and environmental pollution from 2005 to 2015 is generally in a strong positive decoupling and a weak growth decoupling, but the decoupling state of some environmental pollution factors has temporarily deteriorated. The relationship between industrial economic growth and industrial pollutant emissions has eased in the 12th Five-Year Plan.

1 Introduction

The concept of green development regards environmental protection as the prerequisite and endogenous driving force for economic and social development. It emphasizes that the economy and the environment are mutually coordinated and maintained in harmony as a whole. While improving the ability of human sustainable development, it also meets the growing environmental needs. At this stage, the contradiction between economic construction and the ecological environment is becoming increasingly prominent. A series of problems such as resource scarcity, environmental pollution, and ecological imbalances have become bottlenecks that restrict China's economic and social development[1].

The use of decoupling tools to study the relationship among regional economic growth and pollution emissions, energy consumption, and land expansion has been carried out[2-6]. This paper uses decoupling analysis tool to evaluate the decoupling status of Tianjin's economic growth and environmental pollutants from 2005 to 2015, and proposes rmeasures to achieve decoupling of economic growth and environmental pollution. It is hoped that these measures can provide reference for the green development of Tianjin's industry.

2 Decoupling analysis tool

Decoupling means that the interrelationship between two or more physical quantities with a related relationship no longer exists. In the field of resources and environment, decoupling is generally used to describe the process of breaking the link between environmental damage and economic development[7]. The professor of Finnish Future Research Center proposed decoupling elasticity, introduced the concept of elasticity to construct decoupling indicators, and perfected the decoupling model [8]. The Tapio decoupling model is an elastic analysis method based on the time scale as an extension of the OECD decoupling model. The advantage is that it overcomes the difficulty of selecting the base period of the OECD decoupling model and improves the objectivity and accuracy of the decoupling analysis. The Tapio decoupling model formula is:

$$R_j = {\Delta D}/{\Delta G} = \frac{(D_j - D_i)/D_i}{(G_j - G_i)/G_i} \quad (1)$$

Among them, R_j is the decoupling index of economic growth and pollution emissions in the j-th year. ΔD is the rate of change of pollution emissions. ΔG is the rate of change of economic growth. D_j and D_i are the pollution emissions at the end of the study period and the beginning of the year, respectively. G_j and G_i are the economy at the end of the study period and the beginning of the year, respectively.

According to the meaning of the eight states defined by Tapio decoupling, the decoupling states of economic growth and environmental pollution are shown in Table 1.

Table 1. Decoupling states of economic growth and environmental pollution

Decoupled state	ΔG	ΔD	R
Strong positive decoupling	>0	<0	<0
Weak decoupling of growth	>0	>0	0~0.8
Decay strong connection	<0	<0	>1.2
Growth connection	>0	>0	0.8~1.2
Decay connection	<0	<0	0.8~1.2

Growth strong connection	>0	>0	>1.2
Weak decoupling	<0	<0	0~0.8
Strong negative decoupling	<0	>0	<0

3 Decoupling Empirical Analysis

3.1 Data sources

The research data are all from Tianjin Statistical Yearbook. In the study, the economic growth factor used industrial added value to avoid information distortion of the decoupling state of pollutants caused by economic growth being amplified. The indicators that support economic growth and affect environmental pollution are selected from industrial energy consumption, and the environmental pollution factors are selected from industrial wastewater discharge, industrial chemical oxygen demand (COD) discharge, industrial waste gas discharge, industrial sulfur dioxide discharge, and industrial solid waste production. Because the industrial chemical oxygen demand emissions were not counted before 2006, the industrial chemical oxygen demand emissions in 2005 were missing. Since 2015, the statistical caliber of industrial waste gas, waste water and other indicators has changed, so the research period is selected from 2005 to 2015.

3.2 Results and analysis

The statistical data of Tianjin's economic growth and environmental pollution since 2005 is used. Among them, Tianjin's industrial GDP index (1978 = 100) is shown in Figure 1. Calculate the decoupling indices of economic growth relative to industrial wastewater discharge, industrial chemical oxygen demand discharge, industrial waste gas discharge, industrial sulfur dioxide discharge, and industrial solid waste production according to the formula. See Table 2, Table 3, Figure 2, and Figure 3 and Figure 4.

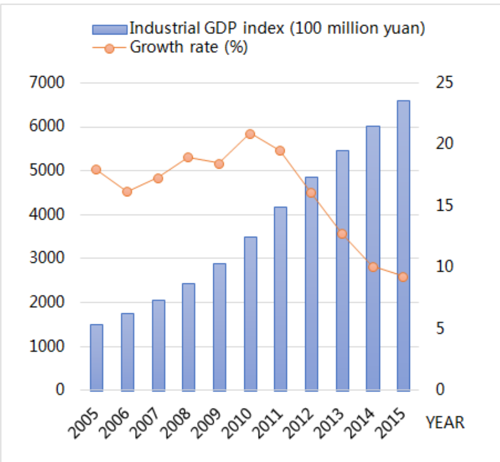

Fig. 1. Industrial GDP index and growth rate from 2005 to 2015

Table 2. Decoupling Index from 2005 to 2015

Year	Energy consumption	Waste water	COD
2005	1.0000	1.0000	-
2006	0.7794	-1.4574	1.0000
2007	0.4877	-0.3859	-0.9713
2008	0.3610	-0.2457	-0.4971
2009	0.4345	-0.2650	-0.8422
2010	0.9851	0.0586	-0.2550
2011	0.7114	0.0302	0.4792
2012	0.4562	-0.2127	0.5898
2013	0.5933	-0.1743	-0.1138
2014	0.2578	0.1690	0.7758
2015	-0.1782	-0.0215	-0.0803

Table 3. Decoupling Index from 2005 to 2015

Year	Exhaust gas	Sulfur dioxide	Solid Waste
2005	1.0000	1.0000	1.0000
2006	2.5615	-0.1980	0.9288
2007	-0.8931	-0.1866	0.4788
2008	0.4769	-0.3511	0.3009
2009	-0.0198	-0.9487	0.1352
2010	1.3618	1.2347	1.0919
2011	0.8227	0.1008	-0.2754
2012	0.0787	-0.1796	0.2432
2013	-0.8265	-0.2798	-0.9721
2014	0.8823	-0.5908	0.8766
2015	-0.5438	-2.2449	-1.2318

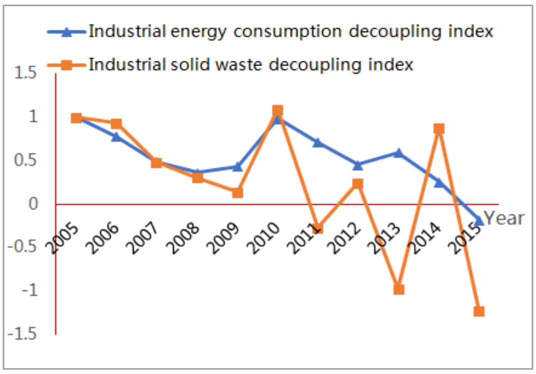

Fig. 2. Decoupling index of industrial economic growth with energy consumption and solid waste

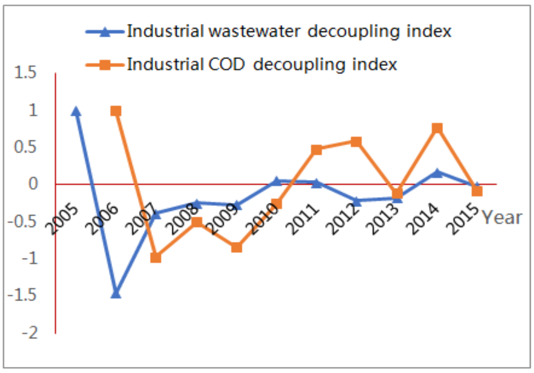

Fig. 3. Decoupling index of industrial economic growth with wastewater and COD

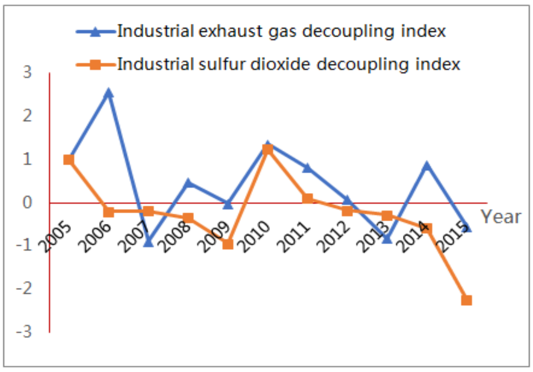

Fig. 4. Decoupling index of Industrial economic growth with exhaust gas and sulfur dioxide

From Table 2, Figure 2, Figure 3 and Figure 4, it can be seen that the decoupling relationship between industrial economic growth and environmental pollution in Tianjin has only four scenarios: strong positive decoupling, weak growth decoupling, growth connection, and growth strong connection. It indicates that Tianjin's industrial economic growth has been in a state of continuous growth since 2005, with an average annual growth rate of 16.0%, and there has been no recession, showing a good development momentum of the industrial economy.

Industrial energy consumption is generally in a weak decoupling of growth. It was in a strong positive decoupling in 2015, but there was a growth connection in 2010. It shows that industrial energy supports the industrial economic growth obviously. Industrial wastewater discharge and industrial chemical oxygen demand are generally in a strong positive decoupling and weak decoupling growth. It shows that industrial wastewater and industrial chemical oxygen demand are basically decoupled from industrial economic growth. Industrial exhaust emissions were in strong decoupling and weak decoupling in the years with more than 50% of growth, but there was a growth connection in 2011 and 2014, and a strong growth connection in 2006 and 2010. This shows that the state of decoupling of industrial exhaust emissions is very unstable. Industrial sulfur dioxide emissions are in a strong positive decoupling and a weak growth decoupling, and in 2010 and 2011 were in a strong growth delink and weak decoupling, respectively. This shows that the national energy conservation and emission reduction policies are effective. The amount of industrial solid waste production is generally in a strong decoupling and weak growth decoupling, but growth links appeared in 2006, 2010 and 2014. This shows that the production of industrial solid waste has been better controlled.

2006 to 2010 is the eleventh five-year plan, and 2011 to 2015 is the twelfth five-year plan. The relationship between industrial economic growth and industrial pollutant emissions has eased in the 12th Five-Year Plan. This may be because Tianjin responded to national policies and took a new road to industrialization during the eleventh five-year plan period. The industrial economy grew rapidly and pollution emissions were high. During the twelfth five-year plan period, Tianjin's industry took a green development path, built a resource-saving and environment-friendly society, and effectively controlled the discharge of industrial pollutants.

4 Questions and suggestions

4.1 Accelerate the green transformation of the industry

The growth of the industrial economy is accompanied by environmental damage. The most effective solution to this problem is to accelerate the industrial green transformation. Implement an innovation-driven strategy, focus on developing emerging industries, and form strategic emerging industry market size advantages and technology leadership advantages. Vigorously develop a green and low-carbon economy, and gradually build an industrial ecosystem characterized by low carbon emissions.

4.2 Implementing a sustainable energy development strategy

From the above analysis, we can see that the development of the industrial economy depends to a large extent on energy consumption. This requires implementing a correct and effective strategy for sustainable energy development. On the one hand, increase the efficiency of energy conversion and get the maximum output with the smallest input. On the other hand, establish the concept of giving priority to energy conservation and invest heavily in the use of clean and renewable energy.

4.3 Attaching importance to pollutant recycling

Aiming at the discharge of industrial pollutants, pollution treatment methods should be innovated. In the treatment of pollutants, the secondary utilization of the resources available in the pollutants is used to maximize the recycling rate of resources and the comprehensive level of waste[9]. The realization of more efficient secondary utilization of related wastes requires researchers to conduct in-depth research on recycling technologies. By improving and optimizing recycling technology, the recycling capacity of available resources will be improved.

5 Conclusion

This paper uses the decoupling analysis tool to calculate the decoupling index of Tianjin's industrial economic growth and the major environmental pollutants of the industry from 2005 to 2015. The results show that since 2005, Tianjin's industrial economic growth has basically been decoupled from industrial wastewater, industrial chemical oxygen demand, and industrial sulfur dioxide emissions. However, it has not yet been completely decoupled from industrial energy consumption, industrial exhaust emissions, and industrial solid waste generation.

The causes of environmental pollution are complex and changeable. This article only analyzes the decoupling of industrial economic growth from major industrial pollutants. In future research, it is necessary to consider the various factors that cause environmental pollution, in order to more scientifically measure the decoupling state and relationship between economic growth and environmental pollution, and provide a reference for the green development path.

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