Study on the decoupling relationship between energy consumption, pollution emission and economic growth in Tianjin and its cause

Hongquan Hao*, Yingchun Wang
School of management, Tianjin university of technology, Tianjin, China

*Corresponding author e-mail: hhq9212@163.com

Abstract. Based on decoupling index, the decoupling of energy consumption, waste gas and waste water emissions and economic growth in Tianjin from 2006 to 2016 was comprehensively compared, and the factors behind each situation were analyzed. The research shows that the average growth rate of energy consumption in Tianjin from 2006 to 2016 is 7.62%. Energy consumption is mainly consumed by the secondary industry. Energy consumption intensity is the main restraining factor to reduce pollution emissions, and the restraining effect is increasing year by year. Economic intensity factors have a positive impact on carbon emissions. Therefore, Tianjin emission reduction can be controlled in such aspects as strictly controlling high-energy consumption industry, increasing technical input and using economic leverage.

Key word: Energy consumption; Pollution emissions; decoupling; Economic growth.

1. Introduction
As China's economic development has entered a new normal characterized by transformation and upgrading, improving quality and efficiency, Tianjin's GDP growth has slowed down significantly, and more attention has been paid to the coordinated and sustainable development of economic society and energy environment. Tianjin is one of the major cities of Beijing-Tianjin-Hebei coordinated development, but because of energy consumption caused by rapid economic development, the problem of pollution is more outstanding, the current our country's economy has been developed from high quality development stage of rapid growth stage, Tianjin should walk road of the transformation of their development, to deal with the relationship between economic development with resources and environment is particularly important.

The concept of decoupling was developed by the organization for economic co-operation and development (OECD), which defined it as a period in which the rate of increase in resource consumption or environmental stress was less than its rate of economic growth Decoupling is divided into three categories: decoupling and negative decoupling and decoupling, and then divided into eight cases to illustrate the relation between decoupling index and type. Foreign scholars have studied the decoupling of resource consumption and economic development earlier. Domestic scholars based on decoupling the research about the relation between resource environment and economic growth [1-2] and decoupling relationship between...
resources and environment pressure and decoupling relationship between economic development and so on [3-4]. Integrated the present research situation and decoupling relationship between resource consumption and pollutant emissions and economic growth of the research is focused on the provincial scale, but less involved in Tianjin. Tapoo.P(2005) [5] made Tapio decoupling index system based on elasticity theory, which has been widely introduced into the fields of urbanization level, resources and environmental management, among which there are abundant research results on the decoupling relationship between economic development and energy consumption.

2. Data sources and research methods

2.1. Data sources

The data selected in this paper are from the data of the National Bureau of Statistics from 2006 to 2016, among which 2006 is the starting year because the statistical data after 2006 are relatively complete and reliable. Economic growth is measured by the gross domestic product (GDP) of Tianjin, the National Bureau of Statistics. The total energy consumption in Tianjin was used as the research data. Pollution emissions were compared by decoupling index calculations of wastewater emissions (including industrial and domestic wastewater) and exhaust emissions (including sulfur dioxide emissions and soot emissions as well as nitrogen oxides) from Tianjin municipal bureau of statistics.

2.2. Decoupling exponent method

Decoupling exponent method [6]:

\[ DS_t = \frac{\Delta E}{\Delta G} = \frac{(E_t - E_0)/(G_t - G_0)}{E_0/G_0} \]

DS\(_t\) represents the decoupling index between energy consumption or pollution emissions and GDP in the t period. E\(_0\) and E\(_t\) respectively represent the energy consumption and pollution emission at the beginning and end of the year in the t period. ΔE represents the change rate of energy consumption and pollution emission; ΔG represents the regional GDP growth rate, and G\(_0\) and G\(_t\) respectively represent the regional GDP at the beginning and end of the year in the T period. The degree of decoupling can be divided into 8 categories as shown in table 1.

| The degree of decoupling | \(\Delta G\) | \(\Delta E\) | \(\Delta E/\Delta G\) | meaning |
|--------------------------|-------------|-------------|---------------------|---------|
| Strong decoupling        | >0          | <0          | (-∞, 0)             | Economic growth is accompanied by a decline in energy consumption and environmental pollution |
| Weak decoupling          | >0          | >0          | (0, 0.8)            | Economic growth is accompanied by rising energy consumption and environmental pollution |
| Recession decoupling     | <0          | <0          | (1.2, +∞)          | Economic recession, while energy consumption and environmental pollution declined |
| Strong negative decoupling| <0          | <0          | (0, 0.8)            | Economic recession, while energy consumption and environmental pollution declined |
| Weak negative decoupling | <0          | >0          | (-∞, 0)             | Economic recession and rising energy consumption and environmental pollution |
| Growth of E consumption  | >0          | >0          | (1.2, +∞)          | Economic growth is accompanied by rising energy consumption and environmental pollution |
| Growth in connection     | >0          | >0          | (0.8, 1.2)          | Economic growth is accompanied by rising energy consumption and environmental pollution |
| Recession connection     | <0          | <0          | (0.8, 1.2)          | Economic recession, while energy consumption and environmental pollution declined |
3. Energy consumption and economic growth in Tianjin

3.1. Economic development of Tianjin
Tianjin is one of the cities with relatively rapid economic development in China in recent years. From 2006 to 2016, calculated at comparable prices in 2005, the total GDP of Tianjin shows a trend of continuous increase. In 2008, the growth rate reached 27.9%, which was the fastest growth rate in the past 10 years. After 2011, the rapid growth turned to stable and sustained growth. As shown in figure 1.

![Figure 1](image1.png)

**Figure 1.** From 2006 to 2016, Tianjin's total GDP with constant price and its growth rate

3.2. Resource consumption and pollution emission in Tianjin
In order to describe resource consumption and pollution emission in a coordinate system, this paper took 2006 as the starting year to conduct unquantified treatment on three indicators representing resource consumption and pollution emission, thus obtaining the change trend chart of resource consumption and pollution emission from 2006 to 2016 (as shown in the figure 2).

![Figure 2](image2.png)

**Figure 2.** Trends in energy consumption and pollution emissions

As can be seen from the figure above, the total energy consumption in Tianjin basically increased from 2006 to 2016. Wastewater discharge increased slowly before 2009, which was relatively fast after 2009, and returned to the previous trend of slowly increasing in 2013. And waste emissions in a downward trend before 2010, appeared a sharp rise in 2011, the main reason is because emissions in 2011 emissions statistics increased nitrogen oxides emissions and smoke dust emissions (powder), this 2011 years ago by the national bureau of statistics statistical (2011 years ago, the national bureau of statistics major statistical sulfur dioxide emissions). From 2011 to 2013, the total emission also showed a declining trend. The total amount of exhaust emission is on the decline trend.

4. Empirical results and analysis
In order to facilitate the presentation of research results, this paper divides the 11 years from 2006 to 2016 into 11 periods (t1-t11), each representing the period from the beginning to the end of the year, as shown in the table 2. In the T5 period, the original data increased the emission of smoke (powder) dust in 2011. In order to observe the trend of decoupling index, this paper still calculated sulfur dioxide
emission in this year, and calculated the remaining periods according to the data of National Bureau of Statistics. According to the evaluation criteria in table 1, the obtained results are analyzed as follows. As shown in figure 3

Table 2. Decoupling index of Tianjin

| Year  | Decoupling index of energy consumption from GDP | Emissions and GDP decoupling index | Wastewater discharge and GDP decoupling index |
|-------|-----------------------------------------------|------------------------------------|-----------------------------------------------|
| T1 (2006) | 0.7375                                        | -0.2645                            | -0.1774                                       |
| T2 (2007) | 0.4567                                        | -0.2281                            | -0.1829                                       |
| T3 (2008) | 0.3024                                        | -0.0688                            | 0.2706                                        |
| T4 (2009) | 0.7616                                        | -0.1150                            | -0.2162                                       |
| T5 (2010) | 0.7098                                        | -0.0289                            | 0.6331                                        |
| T6 (2011) | 0.5069                                        | -0.0800                            | -0.0681                                       |
| T7 (2012) | 0.5719                                        | -0.2453                            | 1.6627                                        |
| T8 (2013) | 0.6324                                        | -0.3472                            | 0.1404                                        |
| T9 (2014) | 0.3753                                        | 0.2737                             | 0.6875                                        |
| T10 (2015) | 0.2738                                      | -2.9992                            | 0.7910                                        |
| T11 (2016) | -0.0229                                    | -5.5208                            | -0.1945                                       |

Figure 3. Decoupling index graph

In general, T3, the decoupling index between energy consumption and economic growth in Tianjin, presented a decreasing trend before T4, and a decreasing trend after T4. However, they have never achieved absolute decoupling, and the state of decoupling is only from weak decoupling in T1 period to strong decoupling in T11 period. This shows that the GDP growth rate of Tianjin is faster than the speed of energy consumption, that is, its economic development is still very dependent on energy consumption. The decoupling index between emissions and economic growth is less volatile. In the whole research range, only one of the emissions and GDP decoupling index is positive, which indicates that the decoupling degree is better. Wastewater discharge and GDP growth index fluctuated greatly during the whole research period. It can be seen that the economic growth of Tianjin at the same time brought the pressure of wastewater discharge is also relatively large [8].

5. Conclusions and recommendations
This paper aims to explore whether the economic growth, energy consumption and environmental pollution emission in Tianjin change in step with each other, and analyze the causes [9]. It calculates the energy consumption and pollution emission in Tianjin from 2006 to 2016. Based on Tapio decoupling model, it analyzes the relationship between economic growth, energy consumption and pollution emission, and draws the following conclusions:
Tianjin’s energy consumption has been increasing year by year, and its pollution emission has been significantly reduced [10]. After 2012, the emission of pollution was greatly reduced, which was related to the implementation of strict environmental regulation policies and the heavy investment in emission reduction technologies during the 12th five-year plan period [11]. Energy consumption intensity is the main restraining factor of pollution emission, and the restraining effect increases year by year.

Based on the above conclusion, in order to promote energy saving and emission reduction in Tianjin, we should pay attention to the synchronous coordination between energy consumption and economic development. (1) continue to reduce Tianjin’s carbon emissions and reduce the proportion of secondary industry with high energy consumption. (2) increase input in technological innovation and reduce energy consumption intensity with the help of economic leverage. (3) increase environmental and ecological compensation.

References

[1] Cui muhua. Decoupling analysis and scenario planning of resource consumption, pollution emission and economic growth in anhui province [J]. Journal of Yangtze river normal university, 2018, 34(06):23-31+124.

[2] Zhong taiyang, huang xian-jin, han li, et al. Research progress on decoupling analysis in the field of resources and environment [J]. Journal of natural resources, 2010(08):166-178.

[3] Duan xiaofeng [1], xu xuegong [1]. Relationship between pollutant emission and economic development level in shandong province [J]. Progress in geographical science, 2010(3).

[4] Wang chongmei. Research on the "decoupling" relationship between regional ecological environment pressure and economic development -- a case study of jiaodong peninsula [J]. Journal of natural science of hunan normal university, 2013, 36(1):91-94.

[5] Tapio P. Towards a theory of decoupling: degrees of decoupling in the EU and the case of road traffic in Finland between 1970 and 2001[J]. Transport Policy, 2005, 12(2):0-151.

[6] Yong X, Mao-Chu Z, Economics S O. Relationship between EKC hypothesis and the decoupling of environmental pollution from economic development: based on China prefecture-level cities' decoupling partition[J]. China Population,Resources and Environment, 2016.

[7] Rajan J B. Technology and environment, J. H. Ausubel and H. E. Sladovich, National Academy Press, Washington, D.C. (1989), 230 pages [isbn no.: 0-309-04075-2] U.S. list price: $35.00[J]. Environmental Progress & Sustainable Energy, 2010, 10(1): F6-F6.

[8] Vidyarthi H. Energy consumption, carbon emissions and economic growth in India[J]. World Journal of Science Technology & Sustainable Development, 2013, 10(4):278 - 287.

[9] Wang Q W, Cai C L, Lu D. Economic Growth, Energy Consumption and Carbon Emissions in China: A Cointegration Analysis[J]. Applied Mechanics and Materials, 2013, 291-294:1616-1619.

[10] Peng S P S, Sun Z S Z. An econometric study of CO2 emissions, energy consumption and economic growth in China[C]// International Conference on Mechanic Automation & Control Engineering. IEEE, 2010.

[11] Schandl H, Fischer-Kowalski M, West J, et al. Global Material Flows and Resource Productivity: Forty Years of Evidence: Global Material Flows and Resource Productivity[J]. Journal of Industrial Ecology, 2017, 22(1).