Decoupling Analysis of the Relationship between Environment Production and Economic Development in Chongqing

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Abstract: In recent years, China's ecological civilization construction has made great achievements, but there are also a series of problems. The main reason is the disharmony between economic development and ecological civilization construction. This paper uses decoupling theory to study the relationship between ecological civilization construction and economic development in Chongqing. The conclusion is as follows: the ecological civilization construction and economic development in Chongqing are in the decoupling state. In the future, Chongqing should focus on improving the quality of human resources and transforming the economic structure, and increase the investment in education and science and technology, so as to improve the level of education and science and technology, and realize the coordination of economic development and ecological civilization construction.

1. Introduction
Great achievements have been made in the construction of ecological civilization in China. At present, scholars have conducted research on the relationship between economic development and ecological civilization construction, and have achieved a series of research results.

Many scholars have carried out relevant research on this issue. The results of the study on the relationship between environment and economy are as follows. Xu Bin and other scholars took Ninghai County in Zhejiang Province as an example to study the relationship between economic development and environmental coordination. The results show that Ninghai County's economic growth and environmental pollution emissions show a "decoupling" trend. In recent years, Ninghai County Government's effective environmental policies and huge environmental investment have effectively curbed the deterioration of the environment to a certain extent, making the relationship between some environmental indicators and per capita GDP present typical characteristics of environmental Kuznets curve, which is in line with the goal of regional sustainable development [1]. Cheng Chao and other scholars have decoupled the economic development level of the urban agglomeration in central Yunnan from the carrying capacity of resources and environment. The results show that the overall level of economic development and the carrying capacity of resources and environment of the central Yunnan urban agglomeration experienced strong decoupling-weak, decoupling-negative, decoupling of expansion-strong decoupling. The decoupling degree and timing of the economic development level, as well as the carrying capacity of resources and environment of each city in the central Yunnan urban agglomeration fluctuated [2]. Wu Yaqi decoupled the relationship between economic development and environmental pollution in Beijing, Tianjin and Hebei, and put forward relevant policy recommendations, including: optimizing the spatial division of labor in the industrial chain; promoting the development of the circular economy; and accelerating regional ecological synergy [3]. Xia Yong and Hu Yabei studied the decomposition of the
causal chain and the internal and external causes of the decoupling between economic development and environmental pollution. The results show that, first, the decoupling of population growth from pollution emissions and economic growth from industrial growth has a positive impact on total decoupling, but the decoupling of industrial growth from population growth has a significant negative impact on total decoupling. Second, the economic agglomeration has the effect of scope economy and positive environmental externality, which helps to decouple economic growth from environmental pollution. Third, by optimizing the industrial structure, the environmental system helps to decouple economic growth from environmental pollution, while measures aimed at stimulating economic growth are difficult to take into account the benefits of resources and environment, and are not conducive to decoupling development [4]. Zhao Zheng decoupled the relationship between economic development and environmental pressure in Beijing. The results show that the overall index of urban environmental pressure in Beijing shows a downward trend year by year. Except for the land pressure index, the other sub-indexes also show a downward trend. The decoupling elasticity index of Beijing's urban economic growth and environmental pressure shows a strong decoupling phenomenon [5].

Han Wenyan and others used decoupling theory to study the relationship between urban water resources utilization and economic development. The results show that the water environment and economy of the four municipalities have not yet reached a coordinated and sustainable development. The development pressure of Chongqing is the greatest, followed by Tianjin. Beijing and Shanghai should avoid weak and negative decoupling[6]. Liu Haiou and others decoupled the relationship between economic development and environmental pollution in Beijing, Tianjin and Hebei. The results show that the decoupling of Beijing-Tianjin-Hebei economy from environment presents a path dependence of deterioration first and then improvement. Spatially, the decoupling status of Beijing is better than that of Tianjin. The decoupling relationship within Hebei Province is more complex, and the improvement in the south is slower than that in the north. Through the analysis of the causes of decoupling, we can see that the path of population growth, technological progress, industrial structure, foreign trade and savings rate have different characteristics [7]. Wei Hongmei used decoupling theory to study the relationship between economic development and environmental pollution under the restriction of environmental regulations. The conclusions are as follows. First, the elasticity of decoupling economic growth from environmental pollution shows convergence characteristics of "steady-state" target convergence. Second, the improvement of formal and informal environmental regulation intensity will help to promote the decoupling of industrial sulfur dioxide, industrial wastewater and economic growth. Third, the elasticity of decoupling economic growth from environmental pollution has a local spatial correlation effect [8]. Based on decoupling theory, Wang Lina analyzed the coordination between the marine economy and marine environment in coastal areas. The results show that the overall level of decoupling between marine economic development and marine environment in coastal areas remains weak, fluctuating and declining. The decoupling levels of 11 coastal provinces and cities are quite different in time and space and tend to expand gradually. The coordinated development trend of marine economic development and marine environment in coastal areas in the next few years is still not optimistic [9]. Wang Naiju and other scholars used cloud model and attribute recognition theory to dynamically evaluate the vulnerability of Tongling's environmental and economic system, and used decoupling theory to analyze the interaction mechanism of environmental system, economic system and subsystems within the environmental and economic system. The results show that, from 2005 to 2014, the environmental system and economic system of Tongling City are mainly strongly decoupled [10]. Han Ruiling and other scholars used the decoupling model to analyze the relationship between economic development and environmental pollution in Tangshan from 1992 to 2014. The results show that, there is a general decoupling between economic development and pollutant emissions in Tangshan in recent years. To some extent, the economic growth of Tangshan depends on the input and discharge of substances [11]. Based on material flow analysis method and environmental Kuznets curve measurement model, Xia Yanqing and Li Shuyin studied the material flow of 31 provinces in China from 1995 to 2014. The results show that, in most cases, economic growth has been relatively "decoupled" from material input or waste discharge, and
the environmental Kuznets curve of ecological pressure indicators in some areas exists [12]. It can be seen that the research results of scholars are relatively rich. However, there is little research on the relationship between economic development and ecological development by using decoupling theory. This is what this paper needs to focus on.

2. Material and Methods

2.1 Material
In recent years, Chongqing has made great achievements in economic and social development. However, there is still disharmony between economic development and ecological development. It is of great significance to use decoupling theory to study the relationship between economic development and ecological civilization construction in Chongqing.

But Chongqing still has problems in energy, environment and economic development. This paper studies the relationship among energy, environment and economy in Chongqing through decoupling theory. Chongqing's energy consumption level is expressed by previous years' energy consumption and environmental quality is expressed in two aspects, namely: chemical oxygen demand emissions from wastewater and sulfur dioxide emissions from exhaust gas, and economic development level is expressed by annual GDP. By consulting Chongqing Statistical Yearbook 2008-2018, we got various data of Chongqing as follows, shown in Tables 1-3.

| Year  | 2008  | 2009  | 2010  | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  | 2017  |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| COD   | 24.2  | 23.9  | 23.5  | 41.7  | 40.3  | 39.2  | 38.6  | 38.0  | 25.6  | 25.3  |

Table 1 Chemical oxygen demand emissions in Chongqing, unit: ten thousand ton

| Year  | 2008  | 2009  | 2010  | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  | 2017  |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| sulfur dioxide emissions | 78.2  | 74.6  | 71.9  | 58.7  | 56.5  | 54.8  | 52.7  | 49.6  | 28.9  | 25.3  |

Table 2 Sulfur dioxide emissions in Chongqing, unit: ten thousand ton

| Year  | 2008  | 2009  | 2010  | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  | 2017  |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| GDP   | 5830  | 6577  | 7984  | 10087 | 11504 | 12894 | 14393 | 15872 | 17741 | 19500 |

Table 3 Chongqing's annual GDP gross unit: 100 million Yuan

2.2 Methods
Decoupling theory is put forward by the economic cooperation organization. It was originally used to study the relationship between economic growth and resource consumption. "Decoupling" means the relationship between the two aspects. Referring to the calculation model of the decoupling index proposed by OECD and the research results of foreign scholars TAPIO and domestic scholars, this paper constructs the following decoupling elastic coefficient model:
Using the decoupling theory and based on the above data, the calculation results are as follows.

The decoupling coefficients between total chemical oxygen demand (COD) and total GDP in Chongqing wastewater are as follows.

3. Results

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Table 5 Types of Decoupling between sulfur dioxide emissions and Total Economic Development in Chongqing

3. Results

Using the decoupling theory and based on the above data, the calculation results are as follows. The decoupling coefficients between total chemical oxygen demand (COD) and total GDP in Chongqing wastewater are as follows.

Table 6 Decoupling coefficient between total chemical oxygen demand emissions and total GDP in Chongqing

The decoupling state between COD and GDP in Chongqing wastewater is as follows.
Table 7 The decoupling status between total chemical oxygen demand emissions and total GDP in Chongqing

| Year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|------|------|------|------|------|------|------|------|------|------|
| Decoupling status | AD | AD | END | AD | AD | AD | AD | AD | AD |

The decoupling coefficients between SO2 emissions and GDP in Chongqing are as Table 8.

Table 8 The decoupling coefficient between total sulfur dioxide emissions and total GDP in Chongqing

| Year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|------|------|------|------|------|------|------|------|------|------|
| Decoupling coefficient | -0.359 | -0.169 | -0.698 | -0.267 | -0.249 | -0.330 | -0.571 | -3.536 | -1.258 |

The decoupling status between SO2 emission and GDP in Chongqing is as Table 9.

Table 9 The decoupling of total sulfur dioxide emissions and GDP in Chongqing

| Year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|------|------|------|------|------|------|------|------|------|------|
| Decoupling status | AD | AD | AD | AD | AD | AD | AD | AD | AD |

4. Conclusion and Discussion

From the results of the above calculation, we can see that the chemical oxygen demand and GDP in Chongqing wastewater show a good interaction state. Except for the expansion and decoupling state in 2011, the rest of the year is in an absolute decoupling state. This shows that Chongqing's economic development has not been at the expense of pollution of the water environment. Chongqing's economic development has embarked on a healthy development track.

The total amount of sulfur dioxide emissions and total GDP in Chongqing's waste gas are absolutely decoupled. It shows that air pollution control in Chongqing has achieved remarkable results in recent years, which also shows that Chongqing's economic development has not been at the cost of polluting the air environment. In 2008, the emission of sulfur dioxide in the air in Chongqing was 782,000 tons. In 2017, the emission of sulfur dioxide in the air was 253,000 tons, a decrease of 67.6% compared with 2008, while the GDP growth rate reached 235%. It can be seen that the two aspects have a close negative correlation.

In summary, it can be seen that Chongqing's environmental pollution and economic development have shown a trend of coordinated development. The reasons for this are mainly the following.

The first reason is the improvement of education quality and population quality. The Chongqing municipal government attaches great importance to improving people's education level. The investment in education is increasing every year. The education expenditure in 2018 is 4.43 times that of 2008, and the number of college students in 2018 is 1.70 times that of 2008. A large number of educational funds have greatly improved the quality of Chongqing's population. High quality population will take the initiative to adopt a more environmentally friendly lifestyle, which is conducive to sustainable economic development and improve the ecological environment.

| Year | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|------|------|------|------|------|------|------|------|------|------|------|------|
| Education expenditure | 153.5 | 190.3 | 240.5 | 318.7 | 399.3 | 437.3 | 469.9 | 536.2 | 575.2 | 626.3 | 680.1 |

Table 11 Number of colleges and universities students in Chongqing

| Year | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|------|------|------|------|------|------|------|------|------|------|------|------|
| Number | 48.5 | 52.3 | 56.6 | 61.3 | 67.0 | 70.8 | 74.1 | 76.7 | 78.5 | 80.5 | 82.8 |

The second reason for the above phenomenon is the increasing level of science and technology investment in Chongqing. As we all know, science and technology are the primary productive forces. It can be seen from the table that the investment in science and technology in Chongqing in 2018 is 4.54 times that in 2008. A large amount of investment in science and technology has greatly improved
the level of science and technology in Chongqing. So that Chongqing can adopt more advanced technology, so as to effectively reduce environmental pollution while developing economy.

| Year   | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|--------|------|------|------|------|------|------|------|------|------|------|------|
| Science Technology expenditure | 15.1 | 15.6 | 17.9 | 25.0 | 33.8 | 38.6 | 38.2 | 45.7 | 51.6 | 59.3 | 68.6 |

The third reason for the above phenomenon is the change of economic structure. It can be output from the table below. From 2008 to 2018, the proportion of the primary industry and the secondary industry in Chongqing's GDP showed a gradual downward trend, while the proportion of the tertiary industry showed a steady upward trend. As we all know, the energy consumption of the tertiary industry is far lower than that of the primary industry and the secondary industry, and the amount of pollutants produced is far lower than that of the primary industry and the secondary industry. Therefore, the change of economic structure makes Chongqing realize the coordination of economic development and ecological civilization construction.

| Year   | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|--------|------|------|------|------|------|------|------|------|------|------|------|
| First industry | 9.9  | 9.2  | 8.6  | 8.4  | 8.2  | 7.8  | 7.4  | 7.2  | 7.3  | 6.9  | 6.8  |
| Second industry | 44.8 | 45.2 | 44.8 | 44.8 | 45.6 | 45.8 | 46.1 | 45.3 | 44.5 | 44.1 | 40.9 |
| Third industry | 45.3 | 45.6 | 46.6 | 46.8 | 46.2 | 46.4 | 46.5 | 47.5 | 48.2 | 49.0 | 52.3 |

References

[1] Xu B, Xu G, Q, Wang W, Zhou Q. Economic growth and environmental coordination—taking Ninghai County as an example. Journal of Capital University of Economic and Business, 2016, 11:25-82

[2] Cheng C, Tong S, Y, Peng H, Y. Analysis of economic development level and resources and environment carrying capacity in the central Yunnan urban agglomeration. Chinese Journal of Agricultural Resources and Regional Planning, 2017, 3:122-131

[3] Wu Y, Q. Study on the Decoupling Relationship between Economic Growth and Environmental Pollution in Beijing—Tianjin—Hebei Region. Yan Shan University, 2017

[4] Xia Y, Hu Y, B. The causal chain decomposition and the internal and external cause of decoupling of environmental pollution from economic growth. Industrial Economics Research, 2017, 5:100-113

[5] Zhao Z. Decoupling analysis between economic development and environmental pressure in Beijing. Urban Question, 2017, 9: 48-54

[6] Han W, Y, Chen X, P, Zhang Z, L. Research on relationship between urban water use and economic growth based on decoupling analysis theory. Bulletin of Soil and Water Conservation, 2017, 10:141-146

[7] Liu H, O, Wu Y, Q, Zhang C, Wang D, D. Spatial—temporal analysis on decoupling economic growth from industrial pollution in Beijing—Tianjin—Hebei region. Journal of Yanshan University, 2017, 11:71-80

[8] Wei H, M. Research of the Decoupling Relation between Economic Growth and Environmental Pollution under the Restraints of Environmental Regulation[D]. Liaoning University, 2017

[9] Wang L, N. The decoupling analysis on coordination between marine economic growth and marine environmental of coastal provinces and cities. Journal of Hebei University of Geosciences, 2018, 2: 58-64

[10] Wang N, J, Huang X, Gao F. Research on vulnerability of environmental economic system based on cloud model in Tongling city. Journal of Central China Normal University, 2016, 12: 914-923
[11] Han R.L, Zhang Q.L, Zhu S.H. Environmental response analysis of Tangshan city’s economic development based on decoupling and VEC Model. Hebei Normal University, 2017, 3: 29-35
[12] Xia Y.Q, Li S.Y. Environmental efficiency evaluation of regional economic systems based on material flow analysis. Resources Sciences, 2017, 39: 1670-1681