Study on the relationship between water resources utilization and economic development based on decoupling theory in Beijing

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Abstract: Since the Chinese government put forward the strategy of ecological civilization, China's ecological environment has been significantly improved. At present, in some places, there is a phenomenon that the ecological environment and economic development are not coordinated. Taking Beijing as an example, this paper uses decoupling theory to study the relationship between water resources use level and economic development in Beijing. The results show that the relationship between water resources use and economic development has been obviously decoupled in Beijing. Beijing government can make further efforts in increasing investment in education, improving the level of investment in science and technology, so as to promote the coordination of water resources utilization and economic development.

1. INTRODUCTION
Since the implementation of the strategy of ecological civilization construction in China, China has paid more attention to resource conservation while paying attention to economic development. Water resource is one of the most important resource. It is of great practical significance to study the relationship between water resource utilization and economic development for promoting the sustainable and healthy development of China's economy. Many scholars have studied the relationship between the use of water resources and economic development, and achieved a series of research results. Tong Guoping and Chen Yan used the decoupling theory to study the relationship between water consumption and economic development [1]. Ma Hailiang and others used the decoupling theory to analyze the provincial differences between industrial wastewater discharge and economic growth [2]. Li Ning and others used the water footprint theory and method to analyze the decoupling of water resources utilization and economic coordinated development of the urban agglomeration in the middle reaches of the Yangtze River [3]. Jia Li and others analyzed Guangxi Beibu Gulf Economic Zone Based on the theory of water footprint, Yi Wuying analyzed the relationship between agricultural water use and economic development in Pingtang County, Guizhou Province

Based on the above research, this paper uses decoupling theory to analyze the relationship between water resources use and economic growth in Beijing, and puts forward corresponding countermeasures and suggestions.

2. Data and methods

2.1. Data
Beijing is the capital of China. In recent years, Beijing has paid close attention to the construction of ecological environment. While great achievements have been made in economic development, the quality of ecological environment has improved significantly. Beijing is a city with serious shortage of water resources, so the Beijing municipal government attaches great importance to economic development and water resources conservation and utilization, and attaches great importance to the coordination of water environment quality improvement and economic development. The following data are related to the economic development and water environment quality of Beijing in recent years. The level of economic development is expressed by GDP, and the amount of water resources used is expressed by the total amount of water used in the whole year.

| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|------|------|------|------|------|------|------|------|------|------|------|
| GDP (100 million yuan) | 14964 | 17188 | 19025 | 21135 | 22926 | 24779 | 27041 | 29883 | 33106 | 35371 |
| Total annual water consumption (100 million tons) | 35.2 | 36.0 | 35.9 | 36.4 | 37.5 | 38.2 | 38.8 | 39.5 | 39.3 | 41.7 |

Source: Beijing Statistical Yearbook 2020

2.2. METHODS
This paper uses decoupling theory to study the relationship between utilization quantity of water resources and economic development in Beijing. The theory of decoupling (DECOUPLING) is a basic theory put forward by the Organization for Economic Cooperation and Development (OECD) to describe the relationship between economic development and resource consumption or environmental pollution.

At the end of the 20th century, OECD introduced the concept of decoupling into agricultural policy research and gradually extended it to the field of environment. The term "decoupling" denotes the interruption of 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:

$$E_{n+1} = \frac{(GP_{n+1} - GP_n)}{(YF_{n+1} - YF_n) / YF_n}$$

In formula (1), n is the nth year, $E_{n+1}$ is the elasticity coefficient of decoupling between water resources use and GDP in the nth + 1 year.

$GP_{n+1}$ is the amount of water resources used in the nth + 1 year. $GP_n$ is the amount of water resources used in the nth year, $YF_{n+1}$ is the total GDP in the nth + 1 year, and $YF_n$ is the total GDP in the nth year.

In this paper, the decoupling elastic coefficient 0.8 and 1.2 are used as the critical values to divide the decoupling state, and the decoupling state is divided into the following eight types, shown in Tables 2.

Table 2. Types of Decoupling between Water Resources Utilization Amount and Total Economic Development in Beijing

| Decoupling condition | Decoupling status     |
|---------------------|----------------------|
| $E\leq0$            | $\Delta GP<0, \Delta YF>0$ | absolute decoupling (AD) |
| $E\leq0$            | $\Delta GP>0, \Delta YF<0$ | absolute negative decoupling (AND) |
| $0<E\leq0.8$        | $\Delta GP>0, \Delta YF>0$ | weak decoupling (WD) |
3. Data analysis results
Using the decoupling theory and based on the above data, the calculation results are as follows.

| Condition | Description |
|-----------|-------------|
| $0 < E \leq 0.8$ | weak negative decoupling (WND) |
| $0.8 < E \leq 1.2$ | expansion connection (EC) |
| $0.8 < E \leq 1.2$ | decline connection (DC) |
| $E > 1.2$ | expansion negative decoupling (END) |
| $E > 1.2$ | recessive decoupling (RD) |

The decoupling coefficient between amount of water resources and economic development in Beijing is shown in Table 3.

Table 3. Decoupling coefficient of water resources amount and GDP in Beijing

| Year | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|------|------|------|------|------|------|------|------|------|------|
| decoupling coefficient | 0.154 | -0.019 | 0.126 | 0.353 | 0.235 | 0.176 | 0.171 | 0.046 | 0.897 |

The decoupling status between amount of water resources utilization and economic development in Beijing is shown in Table 4.

Table 4. The decoupling of total energy consumption and GDP in Chongqing

| Year | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|------|------|------|------|------|------|------|------|------|------|
| decoupling status | WD | AD | WD | WD | WD | WD | WD | WD | EC |

4. Conclusion and Discuss
From the results of calculation, the relationship between water resources use and economic development in Beijing is basically in a decoupling state, and the main reasons can be attributed to several points.

First, the level of education in Beijing has been greatly improved, and the quality of citizens has been greatly improved. As can be seen from Table 5, Beijing's education investment in 2019 will reach 113.7 billion yuan, an increase of 152% over the 45 billion yuan in 2010. Due to the massive increase in investment in education and the general improvement of the quality of the whole people, all the citizens have consciously developed water-saving awareness and formed water-saving habits. This is conducive to the coordination of water saving and economic growth.

Table 5. Beijing financial education expenditure, unit: 100 million Yuan

| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|------|------|------|------|------|------|------|------|------|------|------|
| Education expenditure | 450 | 520 | 629 | 681 | 742 | 856 | 887 | 965 | 1026 | 1137 |

Second, Beijing's investment in science and technology has increased significantly, and the level of science and technology has improved significantly. As can be seen from the table below, Beijing's investment in science and technology in 2019 is 43.3 billion yuan, an increase of 142% compared with 17.9 billion yuan in 2010. Due to the substantial increase in investment in science and technology, Beijing has more research funds to develop more water-saving technologies and equipment, which can greatly save water consumption.

Table 6. Beijing financial science and technology expenditure, unit: 100 million Yuan

| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|------|------|------|------|------|------|------|------|------|------|------|
| Education expenditure | 179 | 183 | 200 | 235 | 283 | 288 | 286 | 362 | 426 | 433 |

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