Research on Decoupling between Economic Development and Water Resource Utilization

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Abstract. The Tapio decoupling model was used to quantitatively evaluate and comprehensively analyse the degree of decoupling, time series evolution and spatial development of economic development and water resources utilization in Guangxi, China from 2006 to 2016. The results show that the impact of Guangxi's economic development on water resources utilization was weakened, which experienced two stages: weak decoupling and strong decoupling. The relations between total water consumption and regional GDP, farmland irrigation water and primary industry GDP were mainly strong decoupling. The relation between industrial water and non-agricultural GDP was mainly weak decoupling. The relationship between water resources utilization and economic growth was relatively good in Yulin, Wuzhou, Baise, Qinzhou and Beihai city, which mainly showed strong decoupling or weak decoupling status, and the economic development still maintain a certain pressure on water resources utilization.

1. Introduction

In the traditional sense, economic growth depends on resources, energy and environmental capacity, but high-consumption, high-emission production methods lead to resource destruction and environmental pollution. Along with the shortage of resources and environmental degradation around the world, the development strategy of “low carbon economy” and the concept of sustainable development have become the development goals pursued by all countries in the world, the core of which is to transform the coupling between economic growth and resource consumption and environmental pollution by transforming or regulating the linear flow model of existing materials, so as to realize the decoupling between economic growth and resource environment[1]. Therefore, scientifically evaluating the relationship between economic growth and the resource environment has become the subject of research in the field of regional sustainable development.

Since the implementation of the national western development strategy, the development strategy of the China-ASEAN Free Trade Area and the development of the Beibu Gulf Economic Zone, the Guangxi economy have achieved great leap-forward development. However, the cost of resource consumption and environmental pollution is often occurred to promote economic growth. The uneven development between the two has not been completely improved, and the pressure on regional economic development still exists. How to break through the resource constraints of economic development, break the link between economic growth and resource occupation, and realize the
decoupling between economic growth and resource environment will be a major problem that must be solved in the process of scientific development in Guangxi. From the perspective of water resources utilization, based on the decoupling theory, this paper quantitatively identifies the decoupling effect of regional economic growth and water resources utilization, reveals the spatial evolution pattern of the decoupling degree, and provides a scientific basis for the coordinated development between regional economic development and water resources utilization.

2. Methodology

2.1. Tapio Elastic decoupling model

In 1992, the Organization for Economic Cooperation and Development (OECD) proposed the concept of decoupling to explore how to block the relationship between environmental quality damage and economic development, and opened up theoretical study of decoupling indicators of international economic activities. Presently, the research on decoupling theory at home and abroad mainly focuses on energy consumption, environmental pollution, land use and so on, and has achieved stage results. In recent years, the decoupling theory has become a hot spot in the academic world to study the coordination of economic development and resources and environment. Decoupling degree measurement and its type division are the core of decoupling research. At present, there are three main methods of measurement: the first is the decoupling factor method proposed by OECD organization; the second is Tapio decoupling index model using elasticity to measure the degree of decoupling; the third is the decoupling evaluation method based on the IPAT equation. In the above methods, the Tapio decoupling model considers the objectiveness and accuracy of the results from the relative quantity and the total amount on the scale of the period, and at the same time, it is more flexible and stable in time selection. Therefore, based on Tapio's elastic decoupling model, this study establishes an elastic analysis model of economic development and water resource utilization.

\[
G_i = \frac{\%\Delta E}{\%\Delta K} = \frac{(E_{\text{end}} - E_{\text{start}})/E_{\text{start}}}{(K_{\text{end}} - K_{\text{start}})/K_{\text{start}}}
\]

Where, \( G_i \) is the elastic coefficient of the i-th period, \( \%\Delta E \) and \( \%\Delta K \) are the elastic change rates of water use change and economic growth, \( E_{\text{start}} \) and \( E_{\text{end}} \) are the water resource utilization index of the starting year and the end year, \( K_{\text{start}} \) and \( K_{\text{end}} \) are the economic indexes of the starting year and the last year.

In order to comprehensively determine the degree of decoupling between economic development and water use change in a certain period, a comprehensive decoupling index is constructed.

\[
RG_i = \frac{\sum_{j=1}^{n} G_{ij}}{n}
\]

Where, \( RG_i \) is a comprehensive decoupling index with the same meaning as \( G_i \). It is mainly used to evaluate the degree of decoupling and the trend of the overall level during the year. \( G_{ij} \) is the elastic coefficient of economic development and j different water use indicators in the i-th period.

2.2. Decoupling degree criterion

To avoid exaggerating the small changes in the amount of change, the decoupling index is generally bounded by 0, and the range of 1.0 to 20% is distinguished from the decoupling and coupling states (Fig. 1).
3. The status of economic growth and water resources utilization in Guangxi

3.1. Economic development in Guangxi
Since 2006, the annual growth rate of Guangxi's GDP had generally been higher than the annual growth rate of the country's GDP. The average annual growth rate of Guangxi's GDP in 2006-2016 reached 14.4%, exceeding the national average of 9.7%. From the perspective of three industrial structures, the secondary industry had the largest contribution rate to Guangxi's economic growth, followed by the tertiary industry, and the overall industrial structure had shown a “two-three-one” trend (Figure 2).

3.2. Water use situation in Guangxi
There are many rivers in Guangxi. In 2016, the surface water resources of the whole autonomous region were 217.7 billion cubic meters, and the groundwater resources were 52.915 billion cubic meters. The drainage areas were 236,700 square kilometers, the annual runoffs were about 197.10 billion cubic meters, and the hydropower reserves were 21.33 million kilowatts.

During 2006-2016, the total consumption of water resources in Guangxi showed a slight downward trend, from 31.44 billion cubic meters in 2006 to 29.06 billion cubic meters in 2016, and farmland irrigation water accounted for more than 50% of the total regional water consumption, and showed a trend of increasing first and then decreasing during the study period. The overall trend of industrial water, residential water, and ecological environment water were little fluctuation (Figure 3).
4. Decoupling of economic growth and water resources utilization in Guangxi

4.1. Analysis on decoupling degree and time series evolution of economic growth and water resources utilization in Guangxi

Since the ratios of domestic water consumption and ecological environment water consumption to total water consumption were very low, and there were no obvious change trend with economic development, this study mainly analyzed the decoupling between economic growth and total water consumption, farmland irrigation water and industrial water. According to the Tapio decoupling index model, the data were processed by formula (1), and the decoupling indexes of economic development and water resources utilization in Guangxi from 2006 to 2016 were calculated to judge the decoupling relationship between economic development and water consumption in Guangxi (Table 1).

Table 1. Decoupling relationship between water consumption and GDP in Guangxi from 2006 to 2016

| time (year) | water consumption and GDP | water for irrigation of agricultural land and primary industry GDP | water consumption for industry and non-agricultural GDP |
|-------------|---------------------------|---------------------------------------------------------------|--------------------------------------------------------|
|             | G relationship            | G relationship                                               | G relationship                                        |
| 2006-2007   | -0.054 Strong decoupling | 0.431 Weak decoupling                                       | 0.101 Weak decoupling                                 |
| 2007-2008   | -0.005 Strong decoupling | -0.947 Strong decoupling                                     | 0.435 Weak decoupling                                 |
| 2008-2009   | -0.265 Strong decoupling | -12.373 Strong decoupling                                    | 0.431 Weak decoupling                                 |
| 2009-2010   | -0.026 Strong decoupling | -0.091 Strong decoupling                                     | 0.090 Weak decoupling                                 |
| 2010-2011   | 0.018 Weak decoupling    | -0.020 Strong decoupling                                     | 0.117 Weak decoupling                                 |
| 2011-2012   | 0.080 Weak decoupling    | -0.097 Strong decoupling                                     | 0.821 Expansion coupling                              |
| 2012-2013   | 0.041 Weak decoupling    | 0.978 Expansion coupling                                     | -0.676 Strong decoupling                              |
| 2013-2014   | 0.032 Weak decoupling    | 0.197 Weak decoupling                                        | -0.158 Strong decoupling                              |
| 2014-2015   | -0.375 Strong decoupling | -0.601 Strong decoupling                                     | -0.367 Strong decoupling                              |
| 2015-2016   | -0.322 Strong decoupling | -0.229 Strong decoupling                                     | -1.134 Strong decoupling                              |

Table 1 showed that:

(1) From the decoupling index of regional GDP and total water consumption, during 2006-2010 and 2014-2016, the decoupling index G of GDP and total water consumption was mainly between (0,
0.4). This showed that economic development was no longer dependent on the consumption of water resources, which was an ideal strong decoupling state. During 2010-2014, the decoupling state changed, and the value of G was mainly between (0, 0.45), the rate of water consumption and the rate of economic change were growing in the same direction, but the rate of water consumption was not much different from the rate of economic growth, which was a weak decoupling state. Overall, the economic development was decoupled from total water consumption in Guangxi.

(2) From the decoupling index of primary industry GDP and farmland irrigation water, during 2007-2012 and 2014-2016, the decoupling index G of primary industry GDP and farmland irrigation water was negative, which was a strong decoupling state. During 2012 and 2014, the decoupling index of farmland irrigation water and the primary industry GDP was positive, showing the trend from expansion coupling to weak decoupling. Particularly, the decoupling index variation in 2008-2009 was due to severe dry weather in some cities and counties in Guangxi, and the precipitation decreased drastically, which led to a greater impact on agricultural production, reduced irrigation water for farmland, so showed significantly strong decoupling. On the whole, the agricultural development and farmland irrigation water were entering a strong decoupling level in Guangxi.

(3) From the decoupling index of non-agricultural GDP and industrial water, during 2006-2011, the value of G was between (0, 0.8), which was a weak decoupling state; during 2011-2012 the value of G was greater than 0.8, and the expansion coupling state appeared; during 2012-2016, the value of G was negative, which was a strong decoupling state. Overall, Guangxi's industrial development and industrial water use were basically decoupled.

4.2. Analysis on the decoupling degree and spatial evolution of economic growth and water resources utilization in Guangxi

According to formula (2), the decoupling indicators of economic development and water resources utilization were calculated in 14 cities from 2006 to 2016, and the spatial distribution maps of decoupling degree between economic growth and water resource utilization were made based on criterion of Figure 1 (Fig. 4).
Figure 4 showed that:

(1) On the whole, during 2008-2009, 2011-2014, due to the impact of dry weather in some cities, agricultural production had been greatly affected, simultaneously, industrial water use increased because some cities were affected by new water companies, there was a state in which economic growth and water use was not decoupled. During the other years of the study period, it was a state of weak decoupling or strong decoupling, and presented a strong decoupling trend in Guangxi.

(2) During the study period, the cities where economic development and water resources utilization were in strong decoupling or weak decoupling were Yulin, Wuzhou, Baise, Qinzhou and Beihai. The other cities all showed a state of expansion coupling or expansion negative decoupling during a certain period.

5. Conclusion

This paper determined the decoupling state of economic growth and water resources utilization in Guangxi based on the Tapio decoupling model, and comprehensively discussed decoupling relation from the perspective of time and space. In general, the dependence of economic development on water resources utilization had weakened, and the decoupling trend was obvious. To achieve sustainable economic development and maintain long-term decoupling between economic development and water use in Guangxi, the following measures can be taken:

(1) Strengthen publicity and guidance, and raise public awareness of water conservation

   The government may strengthen the propaganda and guidance of water conservation. In the life, all the people are involved in the activities of saving water resources, strengthening the management of public water, rationally adjusting the water price, and reducing the waste of water resources in essence; in agriculture, water conservation measures can be adjusted to improve water efficiency by reforming water saving in irrigation areas; industrially, continue to transform water-saving technologies, and actively popularize recycling water, strengthen the recovery of sewage, and improve water efficiency in the industrial sector.

(2) Strengthen management and improve water resources management system

   On the basis of implementing the existing water resources management system, it is necessary to continue to improve the water resources management system, conscientiously implement the water abstraction permit system, severely crack down on unreasonable water use behaviors, and have zero tolerance for water users with old water use processes and very low water use efficiency; focus on water enterprises, increase management, scientifically control industrial water use; continue to
strengthen the unified planning, management and dispatch of water resources, establish an authoritative, efficient and coordinated water resources management system to ensure better use of water resources.

3) Planning water resources engineering landscape and optimizing water resources allocation

Establish a scientific pattern of water resources engineering, and build some reservoir projects and water resources projects, improve water storage capacity and water supply capacity, optimize water resources allocation within the region, and give full play to the engineering value of water resources.

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