Research on the Driving Effect of Industrial Structure Rationalization on the Time Dimension Difference of Regional Total Water Consumption: Taking Yangtze River Economic Belt as an Example

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Abstract: The coordination between output structure and factor endowment is an important focus on studying the resource utilization and decomposition based on the effect of industrial structure. Decompose the effect of industrial structure that affects the time-dimensional difference of the total amount of regional water consumption into rationalization effect of industrial structure, advanced effect of employment structure, industrialization income effect and extraction effect of tertiary industry. Constructing the LMDI decomposition expansion model of the time-dimensional difference of the total amount of regional water consumption, and mainly exploring the specific driving path and internal mechanism of the rationalization of industrial structure. Taking the Yangtze River Economic Belt as an example, it can be concluded that :(1)Rationalization of Industrial Structure is an important driving force to suppress the increase of water consumption in Economic Belt from 2000 to 2020.It is suggested that provinces and cities in the Yangtze River Economic Belt should adhere to the " water saving priority " and comprehensively optimize the allocation of water resources among the three industries.(2)Since 2010, the effect of Rationalization of Industrial Structure on the rise of the total amount of water consumption has declined year by year. At present, the Rationalization of Industrial Structure has reached a high level, and it is weak in restraining the increase of total amount of water consumption. It is suggested that we should improve the knowledge content and innovation density of the three industries, and find a breakthrough point in comprehensively improving the industrial quality.

1 INTRODUCTION

1.1 Research Background

With the continuous growth of China's economic aggregate and the continuous expansion of population scale, the mismatch between water resource endowment and economic development demand has become the main factor restricting the coordinated development of China 's economy, society and ecology. The relationship between water resource endowment and output structure needs to be coordinated as soon as possible. China's 14th Five-Year Plan for Water-saving Society Construction emphasizes :In the new stage of development, we should adhere to the " to use Yellow River water resources as its capacity permits " and resolutely curb unreasonable water demand ; to implement major regional strategies such as the development of the Yangtze River Economic Belt and the integrated development of the Yangtze River Delta, promote ecological priority and green development, and require the implementation of the most stringent water resources management system to save water and expand development space. The key to improving the efficiency of water resources utilization and the quality of economic development lies in optimizing the allocation of water resources among industries and promoting the transformation of water use from extensive and inefficient to economical and intensive. The optimal intensive

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degree of water resources for economic growth depends on the degree of industrial structure optimization and upgrading. The rationalization of industrial structure is closely related to the total amount of regional water consumption.

Digital economy has become a new driving force for the optimization and adjustment of industrial structure. Driven by digitalization, the improvement of the coupling degree of the structure of factor input and output is the main manifestation of the upgrading of industrial structure and the key to achieving high-quality development of China's economy. Rationalization of industrial structure refers to the aggregation quality among industries, which reflects the degree of effective utilization of resources and coordination among industries and is a measure of the coupling degree of the structure of factor input and output. According to the data of the National Bureau of Statistics, the ratio of the product of the output value of the tertiary industry and the employment population of the secondary industry in China to the product of the output value of the secondary industry and the employment population of the tertiary industry in China decreased from 0.44 in 2000 to 0.10 in 2020, indicating that the coupling degree of the structure of input and output of China ' s industrial structure factors is increasing. In view of the operability of the decomposition, the ratio of the product of China ' s tertiary industry output value and employment population in the secondary industry and the product of China' s secondary industry output value and the tertiary industry employment population is selected to measure the rationalization of industrial structure.

1.2 Literature Review

The research on the suitability of resource elements and industrial structure is an important topic in the field of resource economics. At present, the research at home and abroad is mainly based on the following perspectives: ① Based on elasticity, the suitability index of water resources and industrial structure is constructed. Combined with Dagum Gini coefficient and Kernel density estimation, the temporal and spatial differences, contribution rate and dynamic evolution law of suitability change in regional and sub-regional are revealed (Zhang, 2021). ② Based on the correlation matching calculation method, the calculation formula of water deviation coefficient is constructed. Combined with the structural deviation coefficient index, the correlation between industrial structure and water resources consumption structure is calculated (Gan, 2011). ③According to the time dimension index decomposition method, the differences of time dimension of total water consumption are decomposed into production intensity effect, effect of industrial structure, economic scale effect, living intensity effect and population scale effect by using LMDI-I-Model1 (Ang, 2015), and the effect of industrial structure is an important factor to suppress the increase of total water consumption (Zhang, 2019, Zhang, 2020, Nan, 2010).

At present, China ' s economic development presents the form of industrial structure upgrading. The existing research results mainly focus on the driving effect of industrial structure upgrading on the spatial and temporal differences of regional water consumption. In view of the transformation of China 's economy from pursuing rapid growth to pursuing high-quality development, the impact of industrial structure on resource utilization should not only study the upgrading of industrial structure, but also improve the research on the rationalization of industrial structure. Facing the new requirements of China's water-saving society construction planning in the 14th Five-Year Plan, the effect of industrial structure is divided into the water-saving technology effect, the extraction effect of tertiary industry, the rationalization of the effect of industrial structure, the employment structure upgrading effect, the industrialization income effect and the scale effect of urban population. The specific path and internal mechanism of the rationalization effect of the industrial structure on the spatial-temporal difference of the total water consumption are mainly explored, and the Yangtze River urban agglomeration is taken as an example for analysis (Yao, 2019, Ma, 2014).

2 RESEARCH METHODS

Based on LMDI-I-Model1, considering the various driving factors that affect the difference of time dimension of regional total amount of water consumption, decomposing the industrial structure effect, constructing the LMDI decomposition expansion model of time dimension difference of total water consumption. We mainly calculate the annual and cumulative contribution of TL, and the differences within the industry. The variation of total water consumption from period $t-1$ to period t can be decomposed into:

$$
\begin{aligned}
\Delta W_{tot}^{t-1,t} &= W^{t} - W^{t-1} \\
&= \Delta W_{I}^{t-1,t} + \Delta W_{\mathrm{ES}}^{t-1,t} + \Delta W_{SI}^{t-1,t} + \Delta W_{TL}^{t-1,t} + \Delta W_{TI}^{t-1,t} + \Delta W_{P}^{t-1,t} \\
&= \sum_i \omega_i \ln(\frac{I^t}{I^{t-1}}) + \sum_i \omega_i \ln(\frac{ES^t}{ES^{t-1}}) + \sum_i \omega_i \ln(\frac{SI^t}{SI^{t-1}}) + \sum_i \omega_i \ln(\frac{TL^t}{TL^{t-1}}) + \sum_i \omega_i \ln(\frac{TI^t}{TI^{t-1}}) + \sum_i \omega_i \ln(\frac{P^t}{P^{t-1}})
\end{aligned} \tag{1}
$$

$$
\text{Weight}: w_i(W_i^t, W_i^{t\text{-}1}) = \begin{cases} (W_i^t - W_i^{t\text{-}1}) / (\ln W_i^t - \ln W_i^{t\text{-}1}), & W_i^t \neq W_i^{t\text{-}1} \\ W_i^t, & W_i^t = W_i^{t\text{-}1} \end{cases} \tag{2}
$$

W_i^t and W_i^{t-1} are total i industrial water consumption for $t-1$ and t periods, respectively; I^t represents the ratio of total regional water consumption to GDP in t period, $\Delta W_I^{t-1,t}$ represents water-saving technology effect; TI^t represents the ratio of regional GDP and tertiary industry added value in t period., $\Delta W_{TI}^{t-1,t}$ represents tertiary industry extraction effect; SI_i^t represents ratio of regional secondary industry added value to urban resident population in t period, $\Delta W_{SI}^{t-1,t}$ represents industrialization income effect; G_{TL}^t represents the ratio of the product of the tertiary industry added value and the second industry employment personnel and the product of the secondary industry added value and the tertiary industry employment personnel in t period, $\Delta W_{TL}^{t-1,t}$ represents rationalization of industrial structure effect; P^t represents the number of urban resident population in t period, $\Delta W_P^{t-1,t}$ represents scale effect of urban population. ES^t represents the ratio of the employment population of the tertiary industry to that of the secondary industry in t period, $\Delta W_{ES}^{t-1,t}$ represents employment structure upgrading effect.

3 EMPIRICAL ANALYSIS

3.1 Data Declaration

The ' 14th Five-Year ' water-saving social construction plan clearly requires that the city should be determined by water, the land by water, the people by water, the production by water, and the population, city and industrial development also should be rationally planned. The dual control of total water consumption and intensity is implemented to promote the transformation of water use from extensive and inefficient to economical and intensive. Urban agglomeration is an important functional area that supports and leads regional integration and high-quality economic development. Its high-quality development is closely related to the efficient utilization of water resources and the optimization and upgrading of industrial structure. The Yangtze River Delta urban agglomeration is an important engine to support and lead the high-quality and integrated development of the Yangtze River Economic Belt. As a major national strategic development region, the Yangtze River Economic Belt covers 11 provinces and cities including Shanghai, Jiangsu, Zhejiang and Anhui, etc. Although it covers only 21.4 per cent of the country, its population and GDP account for more than 40 per cent of the country. The data of industrial added value, total water consumption and employment population of provinces and cities in the Yangtze River Economic Belt from 2000 to 2020 are derived from the statistical yearbook of provinces and cities and the ' China Water Resources Bulletin'. The industrial added value data are adjusted according to constant prices in 2000.

3.2 Analysis on Driving Effect of Temporal Difference of Total Water Consumption in Yangtze River Economic Belt

The water-saving technology effect (I), employment structure upgrading effect (ES), industrial income effect (SI), rationalization of industrial structure effect (TL), tertiary industry extraction effect (TI) and urban population size effect (P) of the total water consumption change in the economic belt from 2000 to 2020 are shown in table 1. The sum of effects in the same year is denoted as TOT.

Table 1: Decomposition of Total Water Consumption Difference in Yangtze River Economic Belt from 2000 to 2020.

Year interval	SG	TS	WG	WT	TOT
2000～2001	20.08	5.19	-96.40	-88.73	-159.86
2001～2002	39.59	-27.50	-163.03	-109.52	-260.45
2002～2003	69.96	-85.39	-272.85	-66.17	-354.46
2003～2004	53.05	-71.46	-165.06	74.19	-109.27
2004～2005	35.33	-25.51	-203.26	-47.39	-240.83
2005～2006	44.80	-44.86	-243.89	4.19	-239.76
2006～2007	33.50	-18.45	-264.41	-52.58	-301.94
2007～2008	18.39	-5.04	-217.31	-22.75	-226.71
2008～2009	18.67	-6.60	-203.64	-37.09	-228.66
2009～2010	74.22	-129.44	-183.18	-61.29	-299.69
2010～2011	46.01	-73.85	-230.46	2.58	-255.72
2011～2012	19.10	-20.43	-374.25	101.18	-274.40
2012～2013	6.28	9.34	-152.06	-70.21	-206.65
2013～2014	-0.78	18.86	-175.33	-108.90	-266.14
2014～2015	-22.98	69.69	-119.48	-119.99	-192.75
2015～2016	-23.96	70.49	-153.57	-110.23	-217.27
2016～2017	-13.90	45.09	-173.49	-25.89	-168.19
2017～2018	-18.03	51.93	-135.52	-82.18	-183.80
2018～2019	-6.28	25.00	-162.69	-27.89	-171.87
2019～2020	0.54	-3.04	-110.83	-135.32	-248.65
Integrated value	393.60	-215.98	-3800.71	-983.98	-4607.07

(1)From 2000 to 2020, the cumulative effect of industrial structure rationalization was -351.757 billion m³.Rationalization of industrial structure played an important role in restraining the increase of total water consumption. The cumulative effect of industrial structure rationalization from 2000 to 2010 was -222.751 billion m³. The rationalization of industrial structure was not mature enough before 2010, and its ability to curb the rise in total water use was unstable. After 2010, the rationalization of industrial structure tended to be stable, and its effect of restraining the increase in total water consumption come to the best and had since weakened year by year(Seen from Figure 1).From 2000 to 2020, the effect of water-saving technology was the first driving factor to suppress the increase of total water consumption. The cumulative effect value of water-saving technology was -460.707 billion m³, accounting for more than 50 % of all the above suppressing effects. It can be seen that the improvement of water saving technology is particularly important to suppress the increase of total water consumption. The water-saving priority strategy should always be put in the first place in the construction of water-saving society.

(2)As shown in Figure 1, from 2000 to 2020, the cumulative effects of employment structure upgrading and industrialization income on the rise of total water consumption were 13.698 billion m³ and 343.817 billion m³, respectively. The upgrading of employment structure and the increase of industrialization income not only reflect the improvement of the economic development level of the Yangtze River Economic Belt, but also indicate the increase of water demand in the Yangtze River Economic Belt. The industrialization income effect is the main driving factor leading to the increase of total amount of water consumption in the Yangtze River Economic Belt, and the employment structure upgrading effect is a secondary driving factor. From 2000 to 2020, the cumulative effect of the tertiary industry extraction was -17.763 billion m³, which inhibited the total regional water consumption. From 2000 to 2009, the cumulative effect of tertiary industry extraction was -5.376 billion m³, which inhibited the increase of regional water consumption. However, from 2009 to 2012, the extraction effect value of tertiary industry turned to positive and began to promote the increase of total water consumption. From 2012 to 2019, the extraction effect value of tertiary industry turned negative again and continued to restrain the increase of total water consumption. From 2000 to 2020, the cumulative effect of urban population size was 175.723 billion m³, and the increase of urban resident population was one of the important driving factors leading to the increase of total water consumption. In the early stage, the family planning policy and other factors led to the decrease of the total population growth rate and the decrease of the urban population growth rate. With the improvement of urbanization level and the opening of comprehensive two-child policy in the Yangtze River Economic Belt, the growth rate of urban resident population is increasing, and the total water consumption is rising as well. Urbanization level, fertility policy and inter-provincial population mobility lead to the fluctuation of urban population size effect.

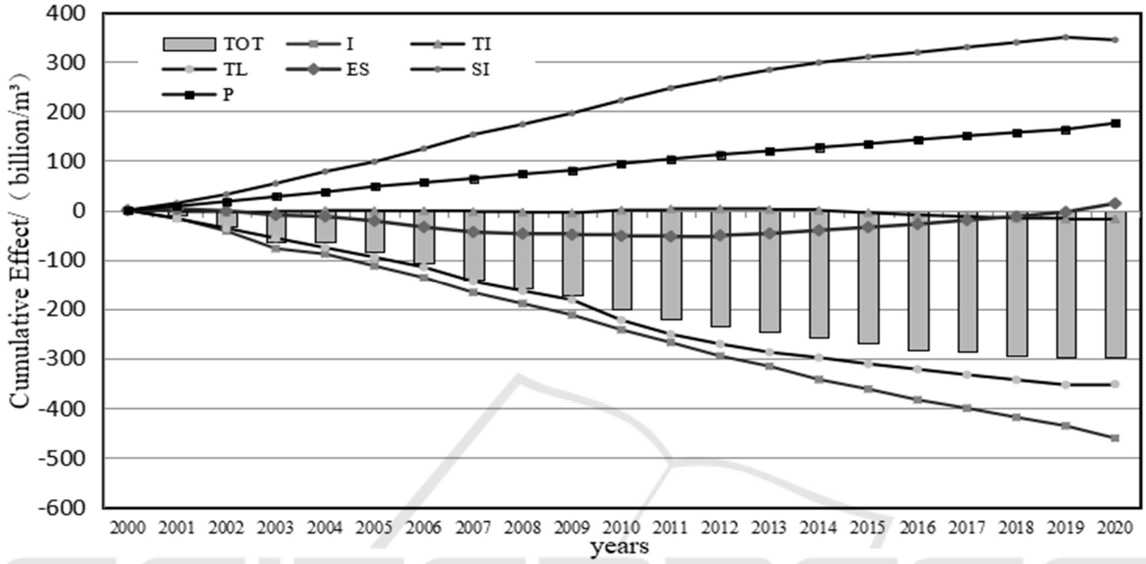

Figure 1: Cumulative effect of total amount of water consumption changes in the Yangtze River Economic Belt from 2000 to 2018.

(3) As shown in Figure 2, the cumulative contribution of the three industrial added values to TL from 2000 to 2020 was -192.141 billion m³, -112.900 billion m³ and -46.716 billion m³ respectively. From 2000 to 2010, the contribution of the three industrial added values to TL showed an overall increasing trend year by year and reached the maximum in 2010. From 2010 to 2020, the contribution of three industrial added value to TL showed a downward trend on the whole and turned to inhibitory effect in 2020.This shows that the continuous decrease in the contribution rate of the added value of the material industry and the continuous increase in the contribution rate of the tertiary industry from 2000 to 2020 have led to an overall upward trend in the AIS value, which has effectively inhibited the increase in the total water consumption of the Yangtze River Economic Belt. After 2010, due to the comprehensive implementation of strict water resources management system, industrial water use efficiency has been greatly improved. Since then, the contribution of the three industrial added value to TL has decreased year by year, and it has been insufficient to restrain the increase of total water consumption only by improving the coupling degree of industrial structure. At this time, it is necessary to pay more attention to the upgrading of industrial structure on the basis of the rationalization of industrial structure, improve the proportion of scientific and technological innovation in the tertiary industry, and inhibit the increase of total water consumption by improving the quality of the tertiary industry and the upgrading of industrial structure.

4 CONCLUSION

(1) The LMDI decomposition expansion model based on the differences of time dimension of regional water consumption focuses on the specific ways and internal driving mechanism of TL to inhibit the increase of total amount of water consumption, which is beneficial to draw policy suggestions on the adaptation between regional water resources and rationalization of industrial structure. From 2000 to 2020 , the improvement of water saving technology has become the main driving force to restrain the

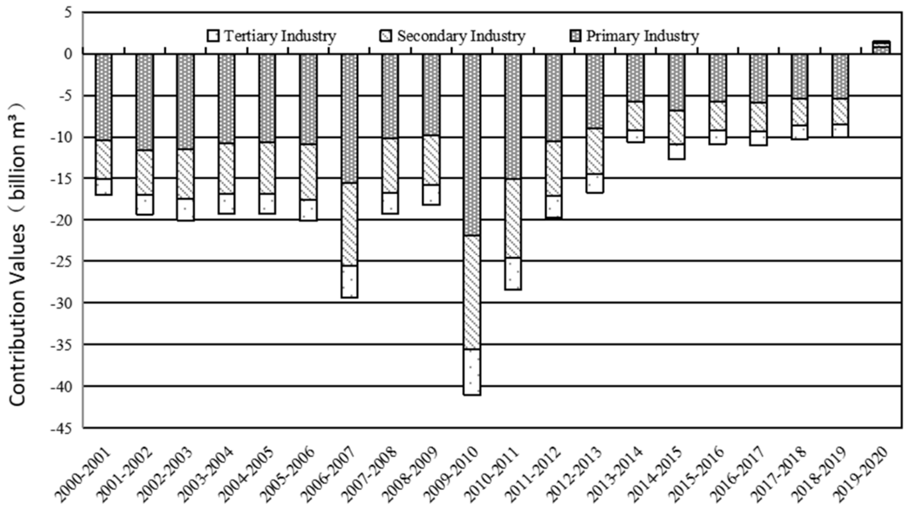

Figure 2: Differences of TL within industry in the Yangtze River Economic Belt from 2000 to 2020.

increase of total water consumption.TL is an important driving factor to inhibit the increase of total amount of water consumption and is quite stable, but its inhibitory effect has weakened year by year since 2010, and it cannot effectively inhibit the increase of total water consumption by 2020.It is worth noting that the tertiary industry extraction effect also has played a certain role in inhibiting the increase in total amount of water consumption, but shows instability. In terms of promoting the increase of total regional water consumption, the increase of industrialization income is the main driving factor, and the improvement of urbanization level is the secondary factor. At the same time, the upgrading of employment structure also has a certain role in promoting the increase of total amount of water consumption.

(2) After 2010, with the decrease of TL ' s inhibitory effect on the increase of water consumption in the Yangtze River Economic Belt, the contribution rate of the added value of the three industries to TL has also decreased year by year. This shows that with the improvement of industrial structure rationalization, it is more and more difficult to restrain the increase of total water consumption only by improving the coupling degree of input and output of the industrial structure. At this time, we should improve the scientific and technological level of the three industries on the basis of the rationalization of industrial structure, and comprehensively improve the quality of the three industries.

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