# Industrial Structure Upgrading and Regional Water Use Intensity Research on the Driving Effect of Time Dimension Difference

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Keywords: Water Resources, Industrial Structure Upgrading, Time Dimension, Water Intensity, Yangtze River Economic Belt.

Abstract: Decomposing the influence of regional water use intensity into industrialization effect, industrial structure upgrading effect, tertiary industry water-saving technology effect, and domestic water extraction effect from the time dimension and constructing the LMDI decomposition expansion model of regional water use intensity time difference. Taking the Yangtze River Economic Belt as an example, the driving channels and internal influence mechanism of industrial structure upgrading on the time dimension difference of water use intensity are deeply explored in this article. The study shows that the upgrading of industrial structure is an important factor that inhibits the water use intensity of the Yangtze River Economic Belt from 2000 to 2020, but its driving effect has changed from negative to positive from 2012 to 2019 to promote the growth of water use intensity. It is suggested that the urban agglomerations along the economic belt should strengthen policy support and scientific management, achieve scientific and technological innovation, and vigorously develop the high-quality water-saving tertiary industry to exert the inhibitory effect of the upgrading of industrial structure on water use intensity.



## 1 INTRODUCTION

China's economy is in an important transition period of rapid development and high-quality development. The contradiction between water resources allocation and regional economic development needs has become a major strategic issue facing the people's livelihood (E, 2020). In China's " 13th Five-Year Plan " action plan of dual control of the total amount and intensity of water resources consumption, it is pointed out that we should adhere to the priority of water-saving and systematic governance, " determine the demand with water " and " adapt to water ", control the total amount and intensity of water resources consumption, comprehensively improve the utilization efficiency and benefit of water resources endowment, and help economic growth and industrial structure transformation and upgrading.

The upgrading of the industrial structure reflects the change in the proportion of the output value of the tertiary industry and the output value of the secondary industry and is a key indicator to measure the level of servitization in the industrial structure. According to the data of the National Bureau of Statistics, China's economic structure has a significant trend of upgrading. The proportion of the tertiary industry in the total output value has risen from 39.88 % in 2000 to 42.73 % in 2020. It is expected that there is still an upward trend. The output value of the tertiary industry continues to increase, the contribution rate of the primary industry is basically stable, the ratio of the output value of the tertiary industry to the output value of the secondary industry is still increasing, the contribution rate of the tertiary industry to social and economic growth is increasing. To further promote the development of a water-saving society, it is important to promote the upgrading of industrial structure and service transformation, improve the proportion of service industry in the tertiary industry, and develop a high-quality tertiary industry. Zhang

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Yu (Zhang, 2020) uses the ratio of tertiary industry output value to secondary industry output value to calculate the index of the advanced stage of industry structure, reflecting the development trend of regional economic structure. For the operability of the model decomposition, this paper also uses the ratio of the output value of the tertiary and secondary industries to measure the index of the advanced stage of industry structure.

## 2 LITERATURE REVIEW

The existing achievements in China and abroad mainly focus on the following aspects. ① The time-dimensional exponential decomposition method. By using the LMDI-I-Model1 model to decompose the various effects of the total amount of water resources utilization in the time dimension, and explore the influence degree and mechanism of different economic effects on water resources endowment (Yao, 2019). ② Multi-method correlation calculation. By using various deviation coefficients, combined with the coordination index, the correlation matching relationship between industrial structure and water resources utilization is calculated. Most of the existing studies have studied the influence of water-saving technology, population size, industrial structure, and income on the total amount of water use in the time dimension, and found that the industrial structure effect has a significant inhibitory effect on the increase of total water use. Compared with the total water consumption research, the research on water intensity is relatively less. Lv Lianghua et al (Lv, 2021) used the total amount of residential water consumption index to reflect the water consumption intensity. Zeng et al (Zeng, 2020) took the water consumption intensity as the decomposition effect of the total amount of water consumption and constructed the LMDI expansion model to indirectly study the influencing factors of water consumption intensity. There were few articles directly using the LMDI model to decompose the water consumption intensity. Based on the previous studies, this paper made innovations from this perspective.

Given the high-level trend of China's economic transformation and the high-level form of industrial structure, this paper decomposes the industrial structure effect into industrialization effect, industrial structure upgrading effect, tertiary industry water-saving technology effect and domestic water extraction effect, and the driving effect of industrial structure on the temporal difference of water intensity in the Yangtze River Economic Belt is analyzed in depth. With the help of LMDI-I-Model1, this paper constructs the LMDI decomposition and expansion model of the time dimension of regional water use intensity and focuses on the driving channels and internal influencing mechanisms of the industrial structure, especially the upgrading effect of industrial structure, on the time dimension difference of water use intensity. This paper uses the relevant data of the Yangtze River Economic Belt as an example for analysis.

## 3 RESEARCH METHODS

### 3.1 Calculation of Time-dimensional Driving Effect

Referring to LMDI-I-Model1, considering various factors affecting the time-dimensional change of water use intensity in the Yangtze River Economic Belt, the LMDI decomposition and expansion model of time-dimensional difference of water use intensity is constructed, and the annual and cumulative effects of industrial structure upgrading on water use intensity are mainly studied. At the same time, the difference in the intra-industry contribution rate is calculated. The variation of water intensity $\Delta \frac{W}{GDP}_{tot}^{t-1,t}$ from period t–1 to period t is decomposed into:

$$\begin{aligned}\Delta \frac{W}{GDP}_{tot}^{t-1,t} &= \Delta \frac{W}{GDP}^{t} - \Delta \frac{W}{GDP}^{t-1} \\ &= \Delta \frac{W}{GDP}_{SG}^{t-1,t} + \Delta \frac{W}{GDP}_{TS}^{t-1,t} + \Delta \frac{W}{GDP}_{WG}^{t-1,t} + \Delta \frac{W}{GDP}_{WT}^{t-1,t} \\ &= \sum_i \omega_i ln\left(\frac{SG^t}{SG_{t-1}}\right) + \sum_i \omega_i ln\left(\frac{TS^t}{TS_{t-1}}\right) + \sum_i \omega_i ln\left(\frac{WG^t}{WG_{t-1}}\right) + \sum_i \omega_i ln\left(\frac{WT^t}{WT_{t-1}}\right)\end{aligned} \tag{1}$$

Among them, the weight is $\omega_i\left(\frac{W}{GDP_i}^{t},\frac{W}{GDP_i}^{t-1}\right)$

$$=\begin{cases}\left(\frac{W}{GDP_i}^{t}-\frac{W}{GDP_i}^{t-1}\right)\Big/\left(ln\frac{W}{GDP_i}^{t}-ln\frac{W}{GDP_i}^{t-1}\right), & \frac{W}{GDP_i}^{t}\neq\frac{W}{GDP_i}^{t-1}\\ \frac{W}{GDP_i}^{t}, & \frac{W}{GDP_i}^{t}=\frac{W}{GDP_i}^{t-1}\end{cases} \tag{2}$$

$\frac{W}{GDP_i}^{t}$ and $\frac{W}{GDP_i}^{t-1}$ are the water intensity of the i industry in the t-1 and t period respectively; $SG^t$ represents the ratio of regional secondary industry output to GDP in period t, and $\Delta\frac{W}{GDP_{SG}}^{t-1,t}$ is the industrialization effect; $TS^t$ represents the ratio of the tertiary industry output to the secondary industry output in period t, and $\Delta\frac{W}{GDP_{TS}}^{t-1,t}$ is industrial structure upgrading effect; $WG^t$ represents the ratio of water consumption of the tertiary industry to the output value of the tertiary industry in period t, and $\Delta\frac{W}{GDP_{WG}}^{t-1,t}$ is the tertiary industry water-saving technology effect; $WT^t$ represents the ratio of total regional water consumption to tertiary industry water consumption in period t, and $\Delta\frac{W}{GDP_{WT}}^{t-1,t}$ is the domestic water extraction effect.

# 4 RESEARCH METHODS

## 4.1 Data Description

The Yangtze River Economic Belt is an important part of China's economy, which plays an important role in promoting the high-quality development of China's economy and the transformation and upgrading of economic structure. At the same time, the economy of the economic belt is based on water, and its high-quality development is inseparably linked to the rational allocation and utilization of regional water resources. The Yangtze River Economic Belt covers Shanghai, Jiangsu, Zhejiang, and other 11 provinces and cities, with 21.4 % of the country's land area accommodating more than 40 % of the population, contributing more than 40 % of GDP. The data of total water consumption and the total industrial output value of each province and city in the Yangtze River Economic Belt from 2000 to 2020 are taken from China Statistical Yearbook, statistical yearbooks of each province and city, and China Water Resources Bulletin. The total water consumption is based on the statistics of water consumption caliber. The total industrial output value data are all based on the 2000 price as the constant price (Zhang 2020).

## 4.2 Driving Effect Analysis of Time Dimension Difference of Water Intensity in Yangtze River Economic Belt

The industrial effect, industrial structure upgrading effect, tertiary industry water-saving technology effect, and domestic water extraction effect of water intensity change in the economic belt from 2000 to 2020 are shown in table I, and the sum of each effect in the same year is recorded as TOT.

Table 1: Decomposition of total water consumption changes in the 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 the data in the table, it can be seen that from 2000 to 2020, the industrial structure upgrading effect is an important influencing factor of water use intensity, which plays an inhibitory role in the increase of water use intensity in the Yangtze River Economic Belt, and the cumulative effect value is -215.98 billion cubic meters / billion. Among them, from 2000 to 2012, the cumulative utility value of industrial structure upgrading is -503.34 billion cubic meters / billion. Since 2001, the industrial structure upgrading has been playing an inhibitory role in the increase of water use intensity in the economic belt. From 2013 to 2019, The driving mechanism of industrial structure upgrading for water use intensity in the economic belt has changed from inhibition to promotion. After 2016, its ability to promote the increase of water use intensity in the Yangtze River Economic Belt has been weakened, and it has turned to inhibition in 2020.

(2) Tertiary industry water-saving technology effect and domestic water extraction effect focus on the internal relationship between tertiary industry water use and the increase or decrease of water intensity. From 2000 to 2020, the cumulative utility value of the tertiary industry water-saving technology effect is -3800.71 billion cubic meters / billion, which is 17.60 times the total utility of the industrial structure upgrading effect. The cumulative utility value of the domestic water extraction effect is -983.98 billion cubic meters / billion, which is 4.56 times the total utility of the industrial structure upgrading effect. The utility values of the two are more than the industrial structure upgrading effect, and the inhibitory effect on the water intensity is more obvious. It can be seen that optimizing the industrial and industrial water use structure, adhering to the water control strategy of “saving water first”, increasing the proportion of the output value of the tertiary industry in the total output value, and the proportion of the water consumption of the tertiary industry in the total water consumption is more conducive to inhibiting the increase of water use intensity.

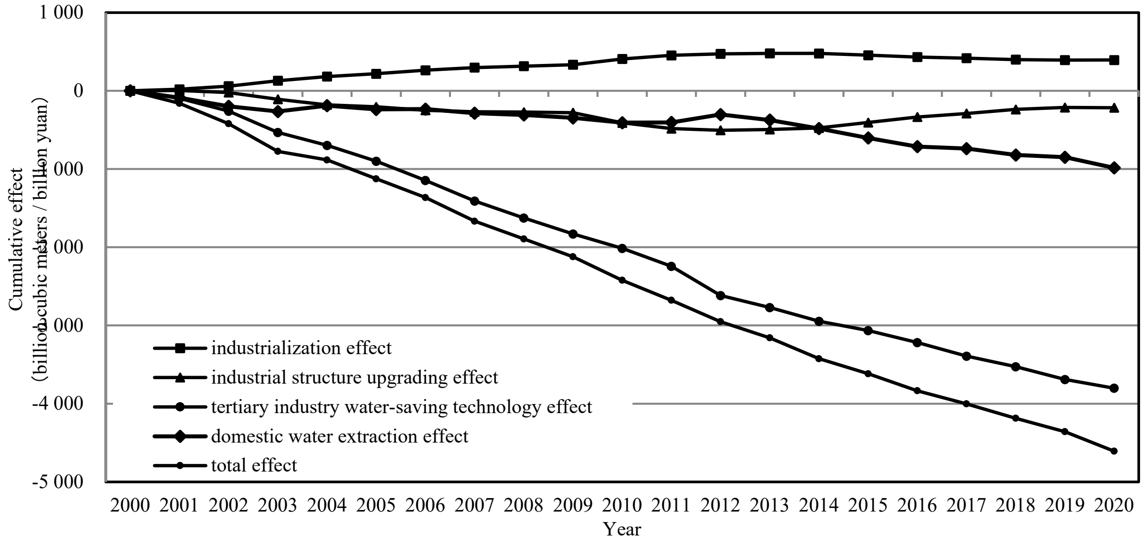


Figure 1: Cumulative effect of water intensity change in economic belt from 2000 to 2020.

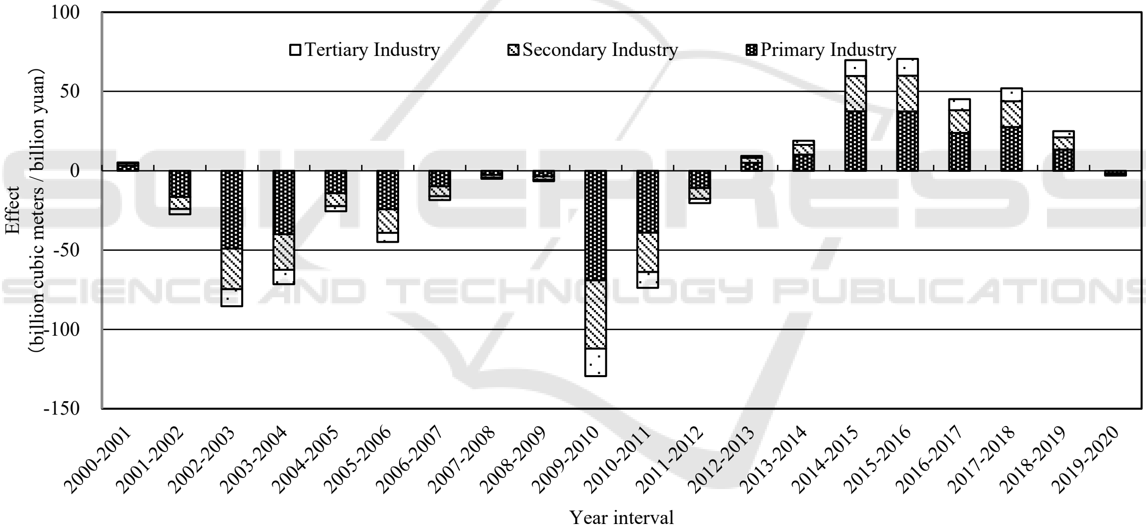


Figure 2: The differences of industrial structure upgrading within the economic belt from 2000 to 2020.



(3) The industrialization effect reflects the industrial development and industrialization level of the Yangtze River Economic Belt, as well as the demand of the secondary industry for water resources, which plays a catalytic role in increasing the water consumption intensity of the economic belt. From 2000 to 2020, the total utility of industrialization effect is 393.60 billion cubic meters / billion. The industrialization effect value from 2000 to 2013 is positive, which drives the increase of water intensity. From 2014 to 2019, the industrialization effect value is negative, which inhibits the increase of water intensity. In 2020, the industrialization effect turns to promote the increase of water intensity. The use of water resources is an important issue in the process of industrialization. Reasonable distribution of industrial structure can weaken the driving effect of industrialization on the increase of water use intensity in the economic belt to a certain extent. However, compared with the utility values of industrial structure upgrading effect, tertiary industry water-saving technology effect, and domestic water extraction effect, it is found that only focusing on industrial structure and relying on industrial structure

adjustment to regulate water use intensity has great limitations.

(4) Studying the effect of industrial structure upgrading within the industry, as shown in Figure 3, 2012 is a significant node. From 2000 to 2012, the cumulative contribution values of the output value of the first, second, and third industries to the upgrading effect of industrial structure is -276.16 billion cubic meters / billion, -161.68 billion cubic meters / billion, and -655.50 billion cubic meters / billion respectively, which played an inhibitory role; from 2012 to 2019, the cumulative contribution value of the output value of the first, second and third industries to the upgrading effect of the industrial structure was 154.74 billion cubic meters / billion, 92.25 billion cubic meters / billion and 43.42 billion cubic meters / billion respectively, which played a promoting role; since 2019, it has turned to inhibition. With the rising contribution rate of the tertiary industry, the utility value of industrial structure upgrading has been effectively increased, and the water intensity of the economic belt has been inhibited from 2000 to 2012. Since 2012, the state has implemented the most stringent water resources management system, strengthened the red line management of water resources development and utilization control, and strictly implemented the total amount of water control. The use of regional water resources has been strictly planned and managed, and the construction of a water-saving society has been comprehensively promoted, which effectively improves the water use efficiency of the three major industries. Therefore, while focusing on the industrial structure, we should pay more attention to the optimization and upgrading of the industry itself (Zhang 2020). Combined with the driving mechanism of the water-saving technology effect of the tertiary industry and the extraction effect of domestic water on water intensity, we should improve the internal proportion of the tertiary industry and develop a more water-saving and high-quality tertiary industry to inhibit the increase of water intensity in the Yangtze River Economic Belt.

# 5 CONCLUSIONS AND POLICY RECOMMENDATIONS

## 5.1 Conclusion

In this paper, the LMDI decomposition expansion model of the time dimension difference of water intensity is constructed to explore the specific mechanism affecting the internal water intensity of the Yangtze River Economic Belt. The effect of water intensity is divided into industrial effect, industrial structure upgrading effect, tertiary industry water-saving technology effect, and domestic water extraction effect. Through data integration and empirical analysis, it is found that the upgrading of industrial structure is an important restraining factor for water use intensity from 2000 to 2020, but its driving effect changed from negative to positive in 2012-2019 promoting the growth of water use intensity. In terms of the other three effects, the tertiary industry water-saving technology effect and domestic water extraction effect are the primary and secondary factors that inhibit the growth of water use intensity in each province and city of the economic belt, while the industrialization effect generally promotes the increase of water use intensity.

## 5.2 Policy Recommendations

### 5.2.1 Optimizing the Inter-Industry Structure and Developing a Higher-quality Tertiary Industry

Provinces and cities should pay attention to the relationship between the upgrading of industrial structure and the water use intensity, adhere to the priority of water-saving strategy (Ma 2014), “ determine the demand with water ” and “ adjust to water ”, continuously increase the proportion of industries and services which have high water use efficiency, continuously improve the industrial quality and the intensity of knowledge economy of the tertiary industry in each province and city, and vigorously support the development of water-saving industries, so as to achieve effective control of water use intensity.

### 5.2.2 Focus on Technology and Promote the Continuous Development of a Water-saving Society

Strengthen the strength of science and technology, strengthen the foundation of science and technology, strengthen the implementation of policies such as the national water-saving action plan, improve the process flow, vigorously develop water-saving technology, optimize the water use capacity of high water consumption industries such as steel and petrochemical, and cultivate water-saving enterprises. Speed up the transformation of theoretical results to the actual, promote the production and industrialization of water-saving technology, and build a water-saving society.

#### 5.2.3 Strengthening the Effective Guidance and Scientific Management of the Government

The governments along the Yangtze River Economic Belt should make differentiated policies according to their different natural conditions and different economic development levels. Optimize the pricing mechanism and use mechanism of water resources, formulate incentive mechanism and punishment mechanism of water use in enterprises, and promote the recycling and sustainable development of water resources utilization.

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