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Study on Effect Decomposition of Spatial-Temporal Difference in Water Consumption in Jiangsu, Zhejiang and Shanghai

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Abstract :In this paper, we use complete decomposition model to analyze the temporal and spatial differences and driving effect of water consumption in Jiangsu, Zhejiang and Shanghai from the four effects of population size, economic development level, industrial structure and industrial water use intensity. The results show that: (1) the driving effect of water consumption change in Jiangsu Province is the effect of economic development level, that in Zhejiang Province is the effect of industrial water use intensity, while that in Shanghai is first the effect of economic development level, which later transfers to effect of industrial water use intensity; (2) the change in water consumption in time dimension is mainly due to the effects of economic development level and industrial water use intensity, while that in space dimension is mainly due to the effects of industrial structure and population size; According to the conclusion, job position adjustment, etc. is proposed so that population structure and quantity can be adjusted and effect of population size can be reduced.

Key words: complete decomposition model; spatial-temporal difference; driving effect; water consumption

1 Introduction

Since the reform and opening up, resource consumption is growing rapidly, especially water consumption. China's water consumption increased from 75.513 billion m^3 in 2000 to 85.61 billion m^3 in 2015. Some scholars draw that matching relationship between water resources, population and GDP was in fluctuating state from data analysis of water resources distribution and economic development in 31 provinces and cities between 2004 and 2009[1];The decomposition model is a common research method to explore the influencing factors of water consumption. Some scholars decomposed the amount of water consumption into structural effect and efficiency effect[2]. Through LMDI addition model, it was decomposed into population effect, regional population distribution effect, regional economic development effect, regional industrial structure effect and regional technological progress effect [3].

However, in the previous study, some studies fail to consider the two dimensions of time and space. This paper explores the factors influencing the change of water consumption in Jiangsu, Zhejiang and Shanghai from time and space dimensions, which will help to take measures to alleviate issues of shortage, uneven distribution and unbalanced combination of water resources .

2 Model settings

In this paper, we use the complete decomposition model proposed by J.W. Sun [4]. Assuming that the target variable is Y which can be decomposed into n factors $(x_1, x_2, x_3, \cdots, x_n)$, and amount of change from the base period to t period is ΔY , then the complete decomposition model can be expressed as:

$$\Delta Y = Y_t - Y_0 = \prod_{i=1}^{n} x_i^t - \prod_{i=1}^{n} x_i^0 = \prod_{i=1}^{n} (x_i^0 + \Delta x_i) - \prod_{i=1}^{n} x_i^0 =$$
$$\sum_{i}^{n} \frac{\prod_{i=1}^{n} x_i^0}{x_i^0} \cdot \Delta x_i + \sum_{i \neq j} \frac{\prod_{i=1}^{n} x_i^0}{x_i^0 \cdot x_j^0} \cdot \Delta x_i \cdot \Delta x_j + \sum_{i \neq j \neq k} \frac{\prod_{i=1}^{n} x_i^0}{x_i^0 \cdot x_j^0 \cdot x_k^0} \Delta x_i \cdot \Delta x_j \cdot \Delta x_k + \Delta x_1 \cdot \Delta x_2 \cdots \Delta x_n \quad (1)$$

According to the principle of "co-creation, equal distribution", the contribution of factor i to target variable Y is:

$$Z_{x_i} = \sum_{i=1}^{n} \frac{\prod_{i=1}^{n} x_i^0}{x_i^0} \cdot \Delta x_i + \frac{1}{2} \cdot \sum_{i \neq j} \frac{\prod_{i=1}^{n} x_i^0}{x_i^0 \cdot x_j^0} \cdot \Delta x_i \cdot \Delta x_j +$$
$$\frac{1}{3} \cdot \sum_{i \neq j \neq k} \frac{\prod_{i=1}^{n} x_i^0}{x_i^0 \cdot x_j^0 \cdot x_k^0} \cdot \Delta x_i \cdot \Delta x_j \cdot \Delta x_k + \frac{1}{n} \Delta x_1 \cdot \Delta x_2 \cdots \Delta x_n \quad (2)$$

Referring to Kaya [5] principle of identical equation, the Eq is as follows:

$$W = \sum_{i=1}^{3} W_i = \sum_{i=1}^{3} P \cdot \frac{G}{P} \cdot \frac{G_i}{G} \cdot \frac{W_i}{G_i} \quad (3)$$

Table 1 Specific meaning of each variable

Variable name	Variable symbol	Variable meaning	Corresponding effect	Effect symbol
Population size	P	Population size	Population size effect	Peffect
Per capita GDP	GDP/P	Level of economic development	Effect of economic development level	PGDPeffect
Proportion of output value	GDPi/GDP	Industrial structure	Industrial structure effect	Seffect
Water use in each industry	Wi/GDPi	Intensity of industrial water use	Effect of industrial water use intensity	Ieffect

3 Data sources

This paper selects the panel data of water consumption, population size and regional GDP of the last year of the "Ninth Five-Year Plan" - "Twelfth Five-Year Plan" periods in Jiangsu, Zhejiang and Shanghai. Total output value of the other years is converted with the year 2000 as the base.

4 Analysis of Empirical Results

4.1 Effect decomposition of time difference of water consumption in Jiangsu, Zhejiang and Shanghai

The change of water consumption in Jiangsu Province is mainly caused by economic development level. The change in water consumption in Zhejiang Province is caused by industrial water use intensity. However, for Shanghai, the reason is first economic development level, then is industrial water use intensity.

4.2 Effect decomposition of space difference of water consumption in Jiangsu, Zhejiang and Shanghai

(1) The difference of water consumption between Shanghai and Zhejiang is decreasing gradually, but the difference in water consumption in 2015 increased. Wherein, difference in industrial water use effect, level of economic development, population size between Shanghai and Jiangsu gradually reduces, difference between Jiangsu and Zhejiang is the result of industrial water use intensity, while change of difference between Shanghai and Zhejiang is caused by the population size effect.

(2) The industrial structure effect between Shanghai and Jiangsu as well as between Shanghai and Zhejiang is gradually increasing, and the industrial structure effect between Jiangsu and Zhejiang reduces first and then increases. Industrial development in Jiangsu and Zhejiang provinces, especially secondary industry development, makes difference in secondary industrial structure between Jiangsu and Zhejiang (negative) gradually reduce. But in 2015, Zhejiang's secondary industrial structure overtook Jiangsu, making difference between Jiangsu and Zhejiang provinces positive, so that industrial structure effect changed from -1.440 billion / m^3 in 2010 to -2.705 million / m^3 in 2015.

Table 2 Shanghai and Jiangsu water consumption difference decomposition effect

	Ieffect	Seffect	PGDPeffect	Peffect	Total
2000	44.37	24.11	-320.52	409.25	337.22
2005	18.03	243.21	-290.28	424.25	395.21
2010	-25.26	256.41	-183.16	375.93	423.92
2015	-44.32	283.86	-126.90	356.86	469.50

Table 3 Shanghai and Zhejiang water consumption difference decomposition effect

	Ieffect	Seffect	PGDPeffect	Peffect	Total
2000	-46.63	109.21	-151.06	181.25	92.77
2005	-99.87	129.48	129.48	176.47	76.60
2010	-119.75	132.37	-103.33	159.39	68.67
2015	-119.21	139.04	-82.19	139.96	77.60

5 Conclusion and Suggestions

5.1 Conclusion

(1) Level of economic development and industrial water use intensity are the main factors causing changes in water consumption. The factor that affects water consumption in Zhejiang is industrial water use intensity, for Jiangsu, is level of economic development. The reason for Shanghai varies from the initial economic development level into the final industrial water use intensity.

(2) Difference of water consumption between Jiangsu and Jiangsu, Jiangsu and Zhejiang gradually increases, while between Shanghai and Zhejiang decreases first and then increases. In addition, the four major effects of the first industry in Jiangsu Province play a dominant role, while that of secondary industry takes the dominant position in Zhejiang and Shanghai.

(3) In overall, level of economic development plays a negative hindering role in water consumption difference between each two areas, population size and industrial structure play positive promoting role, while industrial water use intensity plays positive-to-negative, negative, positive role respectively in water consumption differences between Shanghai and Jiangsu, Shanghai and Zhejiang, and between Jiangsu and Zhejiang.

5.2 Suggestions

Based on the above conclusions, the following suggestions are made:

(1) Jiangsu Province should improve agricultural water use technology, take transformation measures according to the actual economic structure, reduce the proportion of primary industry in economic structure. In addition, Shanghai and Zhejiang should pay attention to improve water use efficiency of secondary industry.

(2) Jiangsu and Zhejiang provinces should reduce the influence of economic development level. When economy is developed to a certain extent, more attention should be paid to industrial water use technology. For Jiangsu, it should control sub-effect of four major effects on primary industry. For Shanghai and Zhejiang, attention should be paid to those on secondary industry.

(3) Gradual increasing difference in water consumption between regions will lead to imbalance in water consumption. Jiangsu, Zhejiang and Shanghai should timely take measures to control population size, for example, adjust the structure and quantity of external population by adjusting job position, so as to prevent huge industrial structure effect brought by industrial structure imbalance.

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