Influence of Economic Structure Optimization on Water Consumption in Shanxi, China

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Abstract. Shanxi province of China is threatened by the water shortage crisis. It is an important means to solve the water shortage problem by rationally water utilization planning and controlling. Using the structural decomposition analysis based on input-output table, the driving factors and driving forces of water consumption in Shanxi is researched, especially the effect of economic structure optimization. On the basis of the input-output table of Shanxi in 2002, 2007 and 2012, a comparable price water input-output model was established in combination with the water use data. According to the study, the improvement of water use efficiency has been the main driving force for reducing water consumption. The change in gross final demand has always been the main driving force for increasing water consumption. The adjustment of manufacturing industry structure, the secondary industry structure, the three industrial structure and the final demand structure have different impacts on water consumption, which has been related to the way of development. On the whole, the optimization of economic structure is changed from water reduction effect to increasing effect.

1. Introduction
Water crisis not only affects water utilization of the society, but also affects national security and development. In particular, the development of cities in northern China has been generally influenced by the shortage of water resources. The development and utilization of regional water resources exceed the carrying capacity. Water for ecological is seriously occupied by the cities for production and living, which bring more and more rivers being dry and polluted. Behind the prevailing water crisis, it is essentially that the way of economic development is not compatible with the capacity of regional water resources.
The economics of Shanxi province base on energy industry. And its development has exceeded the carrying capacity of water resources. According to the water resources bulletin of the Shanxi Province in 2015, the total amount of water used in the province is About 7.55 million cubic meters. The annual average water resource in the local area is 12.38 million cubic meters, the 61% of which has been used by the development of society.
In order to solve the problem of regional water shortage, Shanxi has constantly adjusted its economic structure. The water used for agriculture and industry has declined continuously, and the living water has continued to rise. However, Shanxi still faces problems such as overloading of groundwater, serious water pollution and so on. This paper focuses on the impact of the economic structure optimization on the water consumption, and the results will provide reference for the regulation and control of water resources utilization in Shanxi province.

2. Methodology
Input-output analysis is a research method based on systematicness and structure. It fully depicts the relationship between departments, technology and demand. And it is widely applied in the fields of resources research and environment economics. For example, Li Haiying [1], and Zhang Youguo [2] studied the impact of economic development on China's carbon emission intensity. Structural decomposition analysis based on input-output model is an important way to study the interrelations of resources and environment in economic system. Depending on structure decomposition analysis, we can decompose the economic driving forces behind the utilization of water resources. Using then water comparable input-output model of Shanxi province in 1997~2012 and structural decomposition analysis, the amount of water consumption is related to the economic system.

2.1. Comparable Price Input-Output Model
The basic input-output tables used in this study are from the website of Shanxi Municipal Bureau, including 3 tables in 2002, 2007 and 2012. On the basis of the basic forms, the departments with similarity have been merged. The service industry is divided into three sectors: productive service industry, consumer service industry and public service industry. The model includes 26 departments, and the department code and assortment are shown in Table 1.

In the calculation of comparable prices, 1997 is taken as the base period. Using agricultural products producer price index, industrial producer price index, fixed asset investment and retail price index, the value of agriculture, manufacture (except construction), construction industry, service industry is deflated in 2002, 2007 and 2012. The comparable input-output table of 26 sector is obtained.

| Department | Assortment          | Department                          | Assortment         |
|------------|---------------------|-------------------------------------|--------------------|
| 1          | Agriculture         | 14                                  | Manufacture of metal smelting and rolling |
| 2          | Coal mining         | 15                                  | Manufacture of metal products |
| 3          | Oil and gas mining  | 16                                  | Manufacture of general and special equipment |
| 4          | Metal mining and selecting | 17               | Manufacture of transport equipment |
| 5          | Non-metallic minerals and other mining | 18         | Manufacture of electrical machinery and equipment |
| 6          | Manufacture of food products and tobacco products | 19       | Manufacture of communications equipment, computers and other electronic equipment |
| 7          | Manufacture of textile | 20             | Manufacture of instrumentation and office machinery products |
| 8          | Manufacture of wearing apparel and leather products | 21        | Other manufacturing |
| 9          | Manufacture of wood products and furniture | 22           | Electricity, gas, water and steam supply |
| 10         | Manufacture of paper products and printing, education, sporting products | 23       | Construction |
| 11         | Manufacture of petroleum, coking products and nuclear fuel products | 24       | Productive service |
| 12         | Manufacture of chemical products | 25       | Consumer service |

Table 1. the department of water input-output model
2.2. Water Input-Output Model
According to the water resources bulletin of Shanxi, the use of water includes agricultural water, industrial water and domestic water. According to Li Wei’s study [3], total water consumption in divided into water use of 26 departments. In this way, the water input-output model including 26 departments was obtained. For the economic structure development has influence mainly on industrial water, the domestic water and environmental water is not considered. The comparable water input-output model is shown in Table 2.

| Department          | Intermediate input | Finally demand | Total output |
|---------------------|--------------------|----------------|--------------|
| Added value         | $A^iX$             | $Y^i$          | $X = (I - A)^{-1}Y = LY$ |
| Total input         | $X^T$              |                |              |
| Water use           | $W_1$              | $W_2$          |              |

2.3. Structure Decomposition Analysis
The basic formula of input-output model is as following.

\[ X = (I - A)^{-1}Y = LY \]  \( (1) \)

X is the total output; A is technology coefficient matrix; Y is the final demand (living consumption, government consumption, fixed assets and inventory, export). L indicates Leon Leontief inverse matrix, which reflect department consumption of others.

The value of water consumption of the society could be as following.

\[ W = C^iX = C^iLY \]  \( (2) \)

W is water consumption of industry; \( C^i \) indicates the input intensity of water resources in industry i (industry water consumption coefficient).

In order to study the influence of economic structure optimization, the structure of economic mode is represented by the final demand structure matrix.

\[ Y = MNOSGP \]  \( (3) \)

M is the structure matrix of manufacture industry measured by final demand; N is the structure matrix of the secondary industry measured by final demand; O is the structure matrix of three industrial structure measured by final demand; S to reflect the final demand structure matrix (structure of consumption, fixed assets and inventory, export); G represents net gross final demand.

\[ W = C^iLMNOSGP \]  \( (4) \)

So the changes of W can be expressed as:

\[ \Delta W = W^1 - W^0 = C^1L^1M^1N^1O^1S^1G^1 - C^0L^0M^0N^0O^0S^0G^0 \]  \( (5) \)

0 represents parameter in basic year, and 1 represents parameter in contract year.

According to the research of Dietzenbacher E and Los B [4], the decomposition of formula (5) is not unique, and the number of the results is related to the number of factors n, which is n!. The decomposition of formula (5) is 5040. Research of Fujimagari D [5] and Betts J R [6] indicated that the result of the bipolar decomposition is very close to other results. The bipolar decomposition method is used to calculate the influence to W.

3. Results
3.1. Results Analysis
The results are listed in Table 3, which indicate the influence to water consumption by the factor with the other factors fixed. C represents the technological progress of water use efficiency. The water use was reduced by 2.08 billion cubic meters between 2007 and 2002 because of C, which had illustrated the increasing output of unit water input.
L represents the technological progress based on the intermediate input. From the result, L has decreased the water consumption by 0.84 billion cubic meters between 2012 and 2007, which means that the progress of technology is conducive to saving water.
M is the influence on water consumption by the structure change of manufacturing industry. In 2007-2002, water use decreased 0.09 billion cubic meters coursed by M. In 2012-2007, it increased 2.29 billion cubic meters. The changes of manufacture structure is not conducive to the water resources utilization.
N is the structural change of secondary industry, namely, the structural change of mining industry, manufacture, construction, electricity, gas, water and steam supply and the structural change in the third industries. It is changing towards the direction of reducing water use. O is the structural changes of the three industries. O drive the water consumption increased by 42.72 billion cubic meters in 2012-2007.
S represents the impact of final demand structure changes (structure of consumption, fixed assets and inventory, export) for water consumption, which forced water use increased by 0.95 billion cubic meters in 2007-2002.
G is the effect of gross final demand changes. The increase of gross final demand made water consumption increased by 5.83 and 3.84 billion cubic meters.

| Year       | C   | L   | M    | N    | O    | S    | G    | ΔW  |
|------------|-----|-----|------|------|------|------|------|-----|
| 2007-2002  | -2.07 | -0.31 | -0.09 | 0.03 | -4.05 | 0.95 | 5.83 | 0.29 |
| 2012-2007  | -3.17 | -0.84 | 2.29  | -23.45 | 42.72 | -20.38 | 3.84 | 1.02 |

3.2. Influence of Economic Structure Optimization
M, N, O, and S represent the economic structure, and the structure optimization is the transformation of development way in Shanxi. The most influential factor in water use is O (the three industrial structure). In 2007-2002, the water consumption decreased by 4.05 billion cubic meters forced by O, and in 2012-2007 years, it increased by 42.72 billion cubic meters.

4. Conclusion
The structural decomposition analysis based on input-output model is applied to study the effect of economic structure optimization on water consumption, taking Shanxi province of China as an example. On the basic input-output table of Shanxi province in 2002, 2007 and 2012, the water consumption of 26 departments is calculated using data from water resource bulletin of Shanxi province. The input-output tables has been deflated by production price while 1997 as the base year. The water resource comparable price input-output model is formed.
The results show that the improvement of water use efficiency and technological progress have been an important factor in the reduction of water consumption. And its driving force is increasing. The increase of gross final demand was the main driving force for increasing water consumption, while the driving force had shown a decreasing trend. The influence of M (manufacture industry structure), N (the secondary industry structure), O (the three industrial structure), and S (the internal structure of final demand) to the water consumption varies. In general, the optimization of economic structure is changed from water reducing effect to increasing water effect, which indicates that it is not conducive to the ease of water use problem.

5. Reference
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