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## Influencing Factor Identification of Industrial Water Use Changes in Tianjin and Their Impact Assessment

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### Abstract

Tianjin is one of China's most water-scarce areas but an important industrial base that consumes large volumes of water for industrial purposes. This paper analyzes changes in industrial water use over the past decade and quantitatively estimates the degree of impact of each factor. The results show that the major factors since 2003 have been industrial scale and water efficiency. Additionally, it is shown that industrial restructuring that is not aimed at more efficient use of water has a relatively weak influence on industrial water use.

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### 1. Introduction

Here, industrial water use refers to the use of water in or during industrial production process, including water for manufacturing, processing, cooling, air conditioning, cleaning, boilers, and plant workers. Some progresses have been made in research on industrial water use and demand mitigation measures. Zuo and Chen [1] analyzed the water use situations of six industrial sectors in Beijing, issuing five recommendations on industrial water efficiency. Yuan et al. [2] found a clear upward trend of favoring high water consumption in Yangzhou's industrial sector during the Ninth Five-Year Plan period. Tong et al. [3] forecast industrial water use in target years in Ordos based on the research on changes and indicators of industrial water use. Sun and Li [4] conducted the Kuznets curve analysis of the industrial water situation in Beijing and identified three main determining factors, while Song et al. [5] evaluated water efficiency in Tianjin by analyzing the relationship between industrial output and industrial water consumption. Some researchers

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have also calculated potential industrial water savings in different areas, providing water efficiency recommendations [6-8]. The existing studies, however, are mostly confined to qualitative descriptions of industrial water use changes and rough explorations of the factors influencing industrial water use. Few researchers have quantitatively described the contributions made by different factors to changes in water use. This paper uses the decomposition approach to measure how certain factors contribute to industrial water use.

## 2. Methodology

### 2.1. Industrial Water Use in Tianjin

Tianjin is one of China's most water-scarce cities, with average annual water resources of 1.569 billion m<sup>3</sup>, or 160 m<sup>3</sup> per capita, only 1/15 of the national level [9]. Tianjin is also an important industrial base and China's northern economic center. It has a broad industrial structure integrating 36 sectors, including smelting of ferrous metals and manufacturing of transportation and communications equipment [10]. Due to this industrial production, Tianjin plays a key role in the economic development of the entire northern region [11]. With accelerated urbanization and rapid growth of the urban population, Tianjin's water demand structure has gradually changed in recent years, as seen in a proportional decrease in rural water demand and an increase in urban water demand [12]. In particular, the proportion of water demand that is for industrial purposes grew rapidly from 17.1% to 22.0% during 2008-2012.

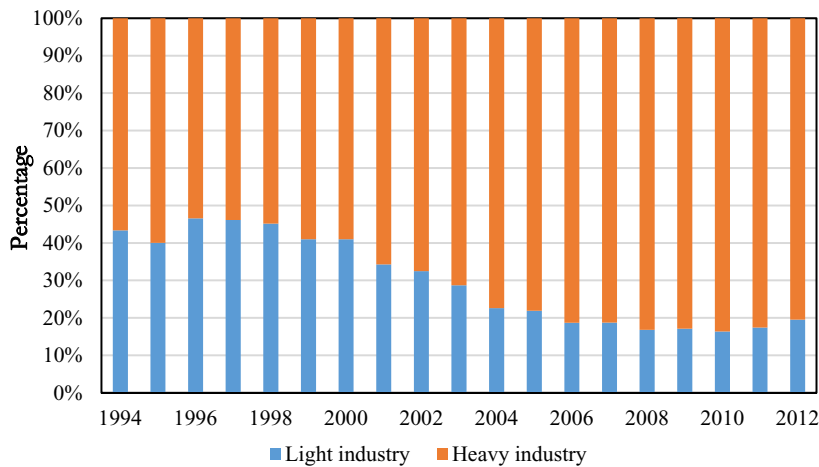


Fig.1. Proportion of light and heavy industries in Tianjin (1994-2012) Source: [13]

### 2.2. Decomposition Method

Industrial water use is influenced by the following three factors: Industrial scale, Water efficiency and Industrial structure. The change in industrial water use relative to the previous year is calculated as follows:

$$\Delta Q = \sum_{i=0}^n [(M_0 + \Delta m)(q_{0i} + \Delta q_i)(\mu_{0i} + \Delta \mu_i) - M_0 \mu_{0i} q_{0i}] \quad (1)$$

where  $\Delta Q$  represents the change in industrial water use,  $M_0$  is the value of industrial output in the previous year,  $q_{0i}$  is water consumption per 10,000 Yuan of industrial added-value in industrial sector  $i$  in the previous year, and  $\mu_{0i}$  is the proportion of the municipality's total industrial output value that came from industrial sector  $i$  in the previous year.  $\Delta m$ ,  $\Delta q_i$ , and  $\Delta \mu_i$  refer to the changes in industrial output value,

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