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A price calculation model for urban residential water and its application

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ABSTRACT

Developing a scientific price calculation model for urban residential water is a prerequisite for water pricing which is to control the amount of water for city's residential use. After comparing different water pricing methods, this article chooses tiered pricing as a basic model and adjusts it by introducing the two variables of "Economic Growth" and the "Population Growth." In this way, the article designs a multivariate and tiered urban residential water pricing model. The article sets relevant parameters and estimates water tariff in Xi'an. The result shows that urban residential water tariff in Xi'an should be rapidly increased in 2020, water tariff for Tier 1 should be raised to 10.92 Yuan/m^3 from 8.21 Yuan/m^3 in 2017, that for Tier 2 should be raised to 15.57 Yuan/m^3 from 11.7 Yuan/m^3, and that for Tier 3 should be raised to 41.93 Yuan/m^3 from 31.50 Yuan/m^3. Such result proves that the model is effective.

Keywords: Water for residential use; Tiered pricing; Economic growth; Population growth

1. Introduction

In China, water supply and water demand are severely out of balance. In 2016, China in total reserved 3246.64 billion cubic meters of water and consumed 604.02 billion cubic meters which accounted for 18.60% of its water storage, far above the world average level. Currently, the amount of national available water resources is relatively small, and water resources are unevenly distributed and overwhelmingly reserved in the south. With only 54% of the national population distributed in the area of the Yangtze River and south of the Yangtze River, the area reserves 81% of national water resources. However, in northern areas, 46% of the Chinese population lives on 19% of national water resources. Water for city's residential use is an important part of national use of freshwater, and Chinese urban residents are consuming more water day by day. Up to now, over 300 cities in China have established their residential water supply systems which provide a daily supply of more than 10 billion cubic meters of water. Besides, the daily water self-supply meanwhile amounts to 170 m^3. However, the increase in urban residential water demand has worsened the imbalance between water supply and water demand in China.

Pricing is significant for demand management [1]. Adjustment of the water tariff is an effective way to control the amount of water for city's residential use. In China, there are generally three pricing methods [2,3]. First, the fixed price water tariff which allows urban residents to pay a fixed amount for a particular duration regardless of how much water they have used. Second, the unit price water tariff which means that every unit of water costs residents the same money and thus the tariff is measured by the amount of water. And third, the tiered pricing water tariff in which certain tiers of water consumption are proposed, each with different unit prices and generally speaking, the larger the amount is, the higher is the tariff. Nevertheless, because of the long-lasting planned economy system and governmental monopoly in the industry of water for city's residential use, proper market mechanisms for price regulation have not been established in China, so it is difficult to manage water demand by pricing. What is more, our surveys show that the

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Chinese government has several problems in urban residential water pricing. For example, it fails to establish multiple management mechanisms and multiple water tariff structures and to assign a reasonable price that is neither too high nor too low [4,5]. As the socialist market economy system continuously deepens, it is of great theoretical and practical significance to study scientific water pricing in urban areas, in a bid to control the amount of water for city's residential use and alleviate the water crisis in China.

Nowadays, researchers have studied water pricing from different perspectives. Centering around such aspects as models, mechanisms, and methods of water pricing, most of the studies put forward various water pricing methods, which has laid a theoretical foundation for researches on the pricing of water for city's residential use [6,7]. In general, existing papers properly combine qualitative and quantitative researches and draw some basic conclusions, including the following: (1) China's pricing model for urban residential water has some disadvantages and fails to meet the requirements of the times, (2) current water tariffs only reflects part of the cost but not all the social cost, (3) apart from employing economics methods, the government should also take the social attribute of water into consideration in order to reasonably price water, and (4) pricing system of urban residential water also needs supporting systems [8,9]. Moreover, few of existing papers take social cost into account [10,11]. When talking about water cost, researchers only take into consideration the cost incurred during the process of supplying water and ignore the impact exerted by water or external factors, especially some non-economic ones. The water ladder price is an international practice in promoting water saving and protecting the interests of water users. That is a question we should consider why the progress of implementing water ladder price scheme is so slow. Only if we constantly improve the pricing mechanism, can we promote the implementation of water ladder price policy and make it to play the role of saving water virtually [12,13].

In this paper, the author employs economic theories to analyze the formation mechanism of prices of water for city's residential use. Moreover, the author improves the current water pricing model and put forward a multivariate and tiered urban residential water pricing model. The article uses the empirical data of Xi'an of Shaanxi Province in China to test the model and successfully proves its effectiveness. Xi'an is the city which is extremely short of water resource in China. Water resource supply is insufficient to meet the various demands.

2. Methodology

2.1. The formation mechanism of prices of water for city's residential use

Water for city's residential use is a type of urban water use. According to the standard of water quantity for city's residential use, city's residents refer to natural persons who live somewhere in cities for a relatively long time and do not migrate frequently. So, water for city's residential use refers to the water consumption of the city's residential for domestic purpose via public or private water supply facilities. Consumers are city's residents and the water is used for household purposes. Water for city's residential use is both a kind of commodity and a type of environmental resource. Therefore, its prices should speak for both its commercial attributes and its social attributes, which mean that prices should reflect not only the cost during the process of supplying this commodity but the property right, the usefulness, and scarcity of this resource.

In urban areas, demand for water can be categorized into two types, namely the demand for water for city's residential use and the demand for water for other purposes. The demand curve of water for city's residential use approximately has three cambers.

Let P denote the price of water for city's residential use while Q denotes the quantity demanded for city's residential use. In Fig. 1, when the water tariff is lower than P_1, residents can well afford it, so the price is relatively inelastic, which means that increase in water tariffs only has a small impact on the variation of water demand. When the price is between P_1 and P_2, urban citizens have a relatively sensitive response to changes of water tariffs, so the price is very elastic, which means that if the price goes up, consumers will use less water and this is advantageous for water conservation. Nevertheless, when the price is higher than P_2, the quantity of residential water use will no longer change regardless of price increase, which has a relatively small impact on the variation of water demand. This is mainly because when the price is between P_1 and P_2, potential for further reducing the quantity of water for city's residential use has been very limited. Even if the price is raised, normal life of urban citizens will not be disturbed, which shows that the price is inelastic.

Normally, the annual supply of water for city's residential use will not vary greatly. Thus, the supply "curve" comes out as a vertical straight line. In some years, as some water conservation projects are completed or restored, the supply of water for city's residential use accordingly increases, but in the next period it will keep stable. The supply of water for city's residential use relies not only on local hydrology factors like precipitation, amount of runoff, and capacity of river systems but also on local water conservation projects. New projects can move the supply curve to the right.

In Fig. 2, the supply is relatively price inelastic, which means that changes in tariffs have an impact on the supply of water for city's residential use. The lines of dashes show that under the influence of factors like water reservation projects, there is an increase in the quantity supplied.

In Fig. 3, D_1 stands for the demand for water for city's residential use while D_2 stands for the demand for water

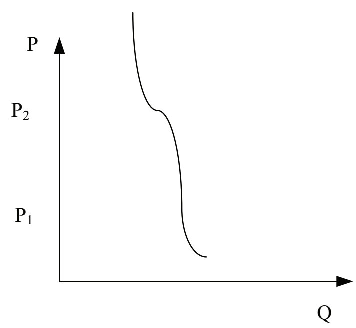

Fig. 1. Demand curve of water for city's residential use.

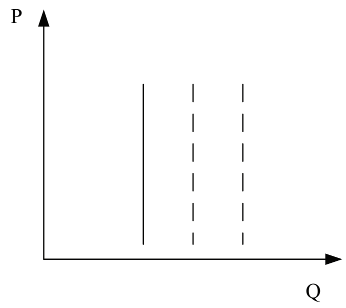

Fig. 2. Supply curve of water for city's residential use.

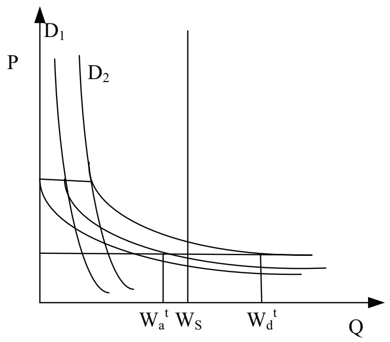

Fig. 3. Water supply and demand.

for other purposes. When it comes to the total urban water demand (D), $D = D_1 + D_2$. When pricing water, the government normally assigns a price lower than the cost, so the water tariff is relatively low. Under this circumstance, quantity demanded W_a^t is smaller than the quantity supplied W_s. With the acceleration of urbanization and the development of economy, the demand curve moves to the right and quantity demanded W_a^t exceeds quantity supplied W_s. According to market mechanisms, the government has to raise the price and when it does, the quantity demanded will keep decreasing until it becomes smaller than the quantity supplied. In this way, water supply is again larger than water demand.

Under the influence of supply and demand, two prices of water for city's residential use are formed, namely the market price that depends on the market rules of supply and demand, and the price that is fixed by the government. Guided by the market price, the government-fixed price has a dominant influence on the quantity demanded of water for city's residential use.

2.2. The price calculation model for urban residential water

After comparing a variety of water resource pricing methods, the author chooses the tiered pricing method as the basic method in water resource pricing calculation model. The main reasons are as follows: (1) It is relatively more difficult to obtain parameters of shadow pricing method, marginal opportunity cost approach, full-cost pricing method, and other pricing methods. (2) The goal of tiered water pricing method is to promote water conservation, accommodate the affordability of users, and compensate costs for reasonable returns, which are in line with the national water pricing policies. The calculation of water resource prices is realistic and feasible. (3) The tiered pricing method can reflect the fairness of water resource pricing. Everyone has the right to use water resources. Meanwhile, water resources, as a commodity, should be priced according to the supply–demand relations. The tiered pricing method takes into account not only disadvantaged social groups' demand for water use but also the relations between market supply and demand. Higher prices for larger water consumers serve the purpose of water conservation. (4) Tiered pricing helps to promote the sustainable use of water resources. Tiered pricing method reflects the consumer's subjective and objective water use. If consumers are unwilling to pay higher prices, they can save water. If they are willing to pay higher prices, then the expenses of their water consumption can offset some of the cost of water delivery, which is conducive to a virtuous circle and sustainable use of water resources.

Tiered pricing method means that low water prices are applied for consumption within a certain amount of water resource use and progressive prices are applied for consumption beyond. The method can be demonstrated as follows:

$$H(q_n) = \begin{cases} q_n \bullet p_1 & q_n \le q_1 \\ q_1 p_1 + (q_n - q_1) p_2 & q_1 < q_n \le q_2 \\ q_1 p_1 + (q_2 - q_1) p_2 + (q_n - q_2) p_3 & q_2 < q_n \le q_3 \\ \ldots\ldots & \\ q_1 p_1 + (q_2 - q_1) p_2 + \ldots\ldots + (q_n - q_m - 1) p_m \, q_{m-1} < q_n & \end{cases} \tag{1}$$

In formula (1), q_n stands for actual water consumption, q_m stands for water consumption in the m tier, and p_m stands for water price for m tier.

The model above can be directly shown in Fig. 4.

Tiered pricing method can ensure basic water supply and promote water conservation while it ignores such dynamic factors as demographic socioeconomy or demographic development is included.

Economic growth has an impact on water prices. On the one hand, economic growth has brought about an increase in water demand. On the other hand, economic growth has also raised residents' capacity to afford higher water resource prices. This article chooses the growth rate of disposable income of urban residents as an indicator of economic growth. At the same time, it also includes the inflation rate that reflects the macroeconomic conditions:

$$e = \frac{I_t}{I_{t-1}} - \theta \tag{2}$$

In Eq. (2), e is economic growth coefficient, I_t is per capita disposable income of urban residents in the year t, and θ is inflation rate.

Economic growth coefficients are directly proportional to water resource prices determined by the market mechanism. The more rapidly the economy grows, the greater the demand for water and the affordability of residents is, resulting in higher water resource prices determined by the market mechanism.

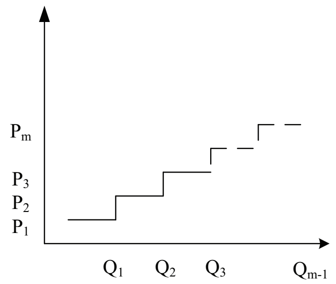

Fig. 4. Diagram of tiered pricing method.

The increase in urban population leads to the increase in water resource demand and scarcity of water resources. The demographic development equation is as follows:

Let $L_{(t)}(j)=\begin{bmatrix} L'_{0,t}(j) & L''_{0,t}(j) \\ L'_{1,t}(j) & L''_{1,t}(j) \\ \vdots & \vdots \\ L'_{w-1,t}(j) & L''_{w-1,t}(j) \end{bmatrix}$ be demographic age state vector. $L'_{i,t}(j)$ and $L''_{i,t}(j)$, respectively, stand for numbers of males and females who are aged i in the year t. $i=0,1\cdots\omega\text{-}1$; $j=1, 2$. $j=1$ represents urban areas. $j=2$ represents rural areas.

Then, the age structure vectors of males and females are as follows:

$$L'_{(t)}(j)=\begin{bmatrix} L'_{0,t}(j) \\ L'_{1,t}(j) \\ \vdots \\ L'_{w-1,t}(j) \end{bmatrix},\quad L''_{(t)}(j)=\begin{bmatrix} L''_{0,t}(j) \\ L''_{1,t}(j) \\ \vdots \\ L''_{w-1,t}(j) \end{bmatrix}$$

According to demographic fundamentals, the main factors that affect the changes in demographic age structure are death rates, birth rates, and population urbanization rates. Therefore,

Let $q_{(t)}(j)=\begin{bmatrix} q'_{0,t}(j) & q''_{0,t}(j) \\ q'_{1,t}(j) & q''_{1,t}(j) \\ \vdots & \vdots \\ q'_{w-1,t}(j) & q''_{w-1,t}(j) \end{bmatrix}$ be demographic death rate state vector. $q'_{i,t}(j)$ and $q''_{i,t}(j)$, respectively, are death rates of males and females who are aged i in urban and rural areas in the year t, where $i=0,1\cdots\omega\text{-}1$, $j=1, 2$.

$b_{(t)}(j)$ means the birth rate in the year t.

$p_{(t)}(j)=\begin{bmatrix} 1-q'_{0,t}(j) & 1-q''_{0,t}(j) \\ 1-q'_{1,t}(j) & 1-q''_{1,t}(j) \\ \vdots & \vdots \\ 1-q'_{w-1,t}(j) & 1-q''_{w-1,t}(j) \end{bmatrix}$ means demographic retention rate vector.

Matrixes of males' and females' demographic retention rates are as follows:

$$p'_{(t)}(j)=\begin{bmatrix} 0 & \cdots & 0 & 0 \\ 1-q'_{1,t}(j) & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & 0 \\ 0 & \ddots & 1-q'_{w-2,t}(j) & \vdots \\ 0 & \cdots & 0 & 1-q'_{w-1,t}(j) \end{bmatrix},$$

$$p''_{(t)}(j)=\begin{bmatrix} 0 & \cdots & 0 & 0 \\ 1-q''_{0,t}(j) & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & 0 \\ 0 & \ddots & 1-q''_{w-2,t}(j) & \vdots \\ 0 & \cdots & 0 & 1-q''_{w-1,t}(j) \end{bmatrix}$$

$U_{(t)}$ stands for urbanization rate in the year t; $\mathrm{SRB}_{(t)}$ for the gender ratio at birth in the year t.

$m_{(t)}=\begin{bmatrix} m'_{0,t} & m''_{0,t} \\ m'_{1,t} & m''_{1,t} \\ \vdots & \vdots \\ m'_{w-1,t} & m''_{w-1,t} \end{bmatrix}$ means age-specific vector of population who transfer from rural areas to urban areas. $m'_{i,t}$ and $m''_{i,t}$, respectively, represent transfer rate of males and females who are aged i in the year t and transfer from rural areas to urban areas. Therefore,

$$m'_{(t)}=\begin{bmatrix} m'_{1,t}(j) & \cdots & 0 & 0 \\ 0 & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & 0 \\ 0 & \ddots & m'_{w-2,t}(j) & \vdots \\ 0 & \cdots & 0 & m'_{w-1,t}(j) \end{bmatrix},$$

$$m''_{(t)}=\begin{bmatrix} m''_{1,t}(j) & \cdots & 0 & 0 \\ 0 & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & 0 \\ 0 & \ddots & m''_{w-2,t}(j) & \vdots \\ 0 & \cdots & 0 & m''_{w-1,t}(j) \end{bmatrix}$$

According to demographic development theories, let

$$A'(j)=p'_{(t)}(j)L'_{(t)}(j)+\begin{bmatrix}1\\0\\\vdots\\0\end{bmatrix}(1-q'_{0,t}(j))\frac{\mathrm{SRB}_{(t)}}{\mathrm{SRB}_{(t)}+100} \times b_{(t)}(j)\sum_{i=0}^{\omega}[L'_{i,t}(j)+L'_{i,t}(j)] \quad (3)$$

$$A''(j)=p''_{(t)}(j)L''_{(t)}(j)+\begin{bmatrix}1\\0\\\vdots\\0\end{bmatrix}(1-q''_{0,t}(j))\frac{100}{\mathrm{SRB}_{(t)}+100} \times b_{(t)}(j)\sum_{i=0}^{\omega}[L'_{i,t}(j)+L'_{i,t}(j)] \quad (4)$$

then,

$$L'_{(t+1)}(j)=A'(j)+(-1)^{j+1}[(A'(1)+A'(2))U_{(t+1)}-A'(1))]m'_{(t)} \quad (5)$$

$$L''_{(t+1)}(j)=A'(j)+(-1)^{j+1}[(A''(1)+A''(2))U_{(t+1)}-A''(1))]m''_{(t)} \quad (6)$$

Demographic estimation model can be made based on Eqs. (5) and (6)

$$L_{(t+1)}(j) = A'(j) + (-1)^{j+1}[(A'(1) + A'(2))U_{(t+1)} - A'(1))]m'_{(t)} + A''(j) + (-1)^{j+1}[(A''(1) + A''(2))U_{(t+1)} - A''(1))]m''_{(t)} \quad (7)$$

then,

$$l = \frac{L_{t+1}(1)}{L_t(1)} \quad (8)$$

where l is the population growth coefficient.

Population growth coefficient has positive correlation to water resource price. When the population increases, the demand for water resources inevitably increases accordingly. When water resource is scarce, only by raising the price of water resources can the water demand and supply be balanced.

Let $H(q_n)$ denote the tax expenses of the n household residents; P denotes the basic water price; q_n denotes the actual water consumption; q_1, q_2, and q_3 denote the critical values of Tier 1, 2, and 3; and Q_1, Q_2, and Q_3 denote the actual water consumption of Tier 1, 2, and 3. Then,

$$H(q_n) = \begin{cases} q_n \bullet p_1 & q_n \le q_1 \\ q_1p_1 + (q_n - q_1)p_2 & q_1 < q_n \le q_2 \\ q_1p_1 + (q_2 - q_1)p_2 + (q_n - q_2)p_3 & q_2 < q_n \le q_3 \end{cases} \quad (9)$$

$$PQ = \sum_{i=1}^{M} H(q_i) = p_1Q_1 + p_2Q_2 + p_3Q_3 \quad (10)$$

Economic growth coefficient and population growth coefficient are included in Eqs. (9) and (10). Then,

$$H(q^0{}_n) = \begin{cases} q^0{}_n \bullet p^0{}_1 & q^0{}_n \le q_1 \\ q_1p^0{}_1 + (q^0{}_n - q_1)p^0{}_2 & q_1 < q^0{}_n \le q_2 \\ q_1p^0{}_1 + (q_2 - q_1)p^0{}_2 + (q^0{}_n - q_2)p^0{}_3 & q_2 < q^0{}_n \le q_3 \end{cases} \quad (11)$$

$$P^0Q^0 = \sum_{i=1}^{M} H(q^0{}_i) = p^0{}_1Q^0{}_1 + p^0{}_2Q^0{}_2 + p^0{}_3Q^0{}_3 \quad (12)$$

$$H(q^t{}_n) = \begin{cases} q^t{}_n \bullet p^0{}_1 \bullet (e \bullet l)^t & q^t{}_n \le q_1 \\ q_1p^0{}_1(e \bullet l)^t + (q^t{}_n - q_1)p^0{}_2(e \bullet l)^t & q_1 < q^t{}_n \le q_2 \\ q_1p^0{}_1(e \bullet l)^t + (q_2 - q_1)p^0{}_2(e \bullet l)^t + (q^t{}_n - q_2)p^0{}_3(e \bullet l)^t & q_2 < q^t{}_n \le q_3 \end{cases} \quad (13)$$

$$P^tQ^t = \sum_{i=1}^{M} H(q^t{}_i) = p^0{}_1(e \bullet l)^t \bullet Q^0{}_1 + p^0{}_2(e \bullet l)^t \bullet Q^0{}_2 + p^0{}_3(e \bullet l)^t \bullet Q^0{}_3 \quad (14)$$

In each tier,

$$p_i^t = p_i^0 \bullet (e \bullet l)^t \quad (15)$$

$$p_i^t = p_i^0 \bullet \left(\left(\frac{I_t}{I_{t-1}} - \theta \right) \bullet \frac{A'_{t+1}(j) + (-1)^{j+1}[(A'_{t+1}(1) + A'_{t+1}(2))U_{(t+1)} - A'_{t+1}(1))]m'_{(t)} + A''_{t+1}(j) + (-1)^{j+1}[(A''_{t+1}(1) + A''_{t+1}(2))U_{(t+1)} - A''_{t+1}(1))]m''_{(t)}}{A'_t(j) + (-1)^{j+1}[(A'_t(1) + A'_t(2))U_{(t)} - A'_t(1))]m'_{(t)} + A''_t(j) + (-1)^{j+1}[(A''_t(1) + A''_t(2))U_{(t)} - A''_t(1))]m''_{(t)}} \right)^t \quad (16)$$

3. Results and discussion

3.1. Parameters

In this paper, urban residential water use in Xi'an of Shaanxi Province in China is applied in the research. Prices between 2017 and 2020 are calculated.

(1) Water volume base and corresponding water price setting in Tier 1. In the calculation range, 1.50%, the average ratio of water expenses to income of families with minimum living allowances in Xi'an is chosen to be the ratio of water expenses to income of families with minimum living allowances in Xi'an. According to Eq. (16), water volume and water price in Tier 1 are calculated.

(2) Water volume base and corresponding water price setting in Tier 2. With reference to residential income, family types, water consuming population, and water for residential use in Xi'an, water volumes and water prices in Tier 2 are calculated according to Eq. (16).

(3) Price setting in Tier 3. Generally, the water price of the highest tier is three to six times of the lowest tier. The average ratios of the highest level of water prices to the lowest level in South Korea, Philippines, Nepal, Thailand, and Indonesia is 3.84. This paper lets water price in Tier 3 to be 3.84 times water price in Tier 1.

(4) Economic growth coefficient. According to the Statistical Yearbooks of Xi'an from 1991 to 2017, the economic growth coefficient for 1990–2016 is available. The grey system forecasting method is applied to predict the economic growth coefficient during 2017 and 2020.

(5) Population growth coefficient. The population age state vector, population death rate state vector, population birth rate state vector, population urbanization rate, gender ratio at birth, gender-specific and age-specific "country to city" migrants' proportion to the total number of migrants, and other parameters are based on the 2010 census data.

3.2. Calculation results

According to the result of parameter setting, the tiered pricing of water for urban residential use from 2017 to 2020 in Xi'an is calculated as shown in Table 1.

Table 1 shows that in 2017–2020, water price in Xi'an is supposed to increase rapidly. Water price in Tier 1 will be 8.21 Yuan/m^3 in 2017, and will increase to 10.92 Yuan/m^3 in 2020, 1.33 times of 2017's with average annual increase

Table 1
Tiered water price calculation results from 2017 to 2020 in Xi'an

Year	Water use (m^3)		
	0–4	4–14	Over 14
2017	8.21 Yuan/m^3	11.70 Yuan/m^3	31.50 Yuan/m^3
2018	9.03 Yuan/m^3	12.86 Yuan/m^3	34.65 Yuan/m^3
2019	9.93 Yuan/m^3	14.15 Yuan/m^3	38.12 Yuan/m^3
2020	10.92 Yuan/m^3	15.57 Yuan/m^3	41.93 Yuan/m^3

of 9.97%. The water price in Tier 2 will increase from 11.7 Yuan/m^3 in 2017 to 15.57 Yuan/m^3 in 2020 with an increase of 3.87 Yuan/m^3. Water price in Tier 3 will rapidly grow from 31.50 Yuan/m^3 in 2017 to 41.93 Yuan/m^3 with the largest increase of 10.43 Yuan/m^3.

The main factors contributing to the rapid growth of water prices for residential water in Xi'an are economic growth and population growth. The combined effects of the two have led to an average increase of 10% annually. It can be forecast that in the coming decade, with the rapid economic growth of Xi'an, the urban population will also rapidly increase, thus worsening the water resource scarcity in Xi'an. In order to regulate the water supply–demand relation, water prices should be raised continuously. Besides, the solution of this problem in the city is still far from perfect by mere means of increasing supply, effective needs management shall be conducted. A rational water pricing system should firstly be built for water-saving society establishment, so as to optimize water resources allocation by means of price leverage.

4. Conclusion

Price is an important tool to adjust demand. By regulating the price of water for urban residential use, the water consumption of urban residents can be effectively controlled. This paper chooses tiered pricing as a basic model and adjusts it by introducing the two variables of "Economic Growth" and the "Population Growth" and tests the new model by using empirical data of Xi'an. The study finds that the price of water for urban residential use should increase rapidly. Water price in Tier 1should increase from 8.21 Yuan/m^3 in 2017 to 10.92 Yuan/m^3 in 2020, that in Tier 2 from 11.7 Yuan/m^3 in 2017 to15.57 Yuan/m^3 in 2020, and that in Tier 3 from 31.50 Yuan/m^3 in 2017 to 41.93 Yuan/m^3. The implementation of tiered water pricing must be guaranteed by policies and regulations of government departments. This paper suggests the establishment of standardized laws and regulations on the setting and adjustment of water resource prices to advance the reform of the pricing model of water use and to promote water conservation.

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