The Research on Price Elasticity of Agricultural Water Demand in Chahayang Irrigation Area

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Abstract According to economics theory and by studying the price elasticity of agricultural water demand, the effects of water price on the agricultural water demand were analyzed and quantitative interrelation between them were determined. By applying the methodology of econometrics, price elasticity of the water demand was derived through construction of agricultural water demand function for Chahayang irrigation area. Furthermore the quantitative study of Chahayang irrigation area was done by using elasticity function of agricultural water demand. The study indicated that agricultural water price has a significant inhibiting effect on water demand. According to the problems of agricultural price of Chahayang irrigation area, some ideas of water supply price reform were proposed. The results can provide reference for the management of water resources.
Key words water price, agricultural water demand, price elasticity of water demand, water price reform

1 Introduction

China is the one of the worst short of water in the world. The question of lacking water exists continuously and becomes more and more serious. But the phenomenon of wasting water resources exists generally. At present, there are major three parts uses of water resources, i.e. domestic, industrial and agricultural. The irrigated farming accounts for over 65% of the country's total water consumption in china. Surface irrigation is the major irrigation method. The area of water-saving irrigation has occupied about 35% of effective irrigation area, but over 80% in some developed countries. The utilization coefficient of irrigation water is only about 0.45. Because of many reasons but especially in order to promote irrigation crops, governments tend to favor the agricultural sector. A primary consequence is that, even in developed countries, the price of agricultural water is far below its economic value. As a practical result, farmers often pay little or nothing for water and, consequently, these politics due to the inefficiency of water use. The inefficiency of water use is the apparent lack of proper pricing of agricultural water. Many practices have been indicated that proper pricing of agricultural water was important for water-saving and efficiency of water use. At the same time, the proper pricing of agricultural water will play a more and more important role in optimizing water resources collocation [1]. Therefore, research on price elasticity of water demand possesses important practical significance. The water demand can be inhibited by water price regulation, and rational utilization of water resources and sustainable development will be realized.

2 A Research Review on Price Elasticity of Water Demand

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Because the quantity of influence factors of agriculture water demand are more and it is more difficult to study on price elasticity, the price elasticity study of the resident water demand is more than of agricultural water demand in China. Shen Dajun [2]etc. ascertained and analyzed the urban residential water demand functions of the country, the urban residential water demand functions of the whole country and six regions of China are developed. Worked out the national Demand-price Elasticity is -0.33, Demand Income Flexibility is 0.56. Wang Ying[3] calculated the Demand-price Elasticity and Demand Income Flexibility of Beijing city between 1981 and 2000 is -0.164 and 0.388, while analyzing the influence in Mounicipal Water Demand that the income of the residents in Beijing city and water price. Pei Yuansheng[4] etc. in elasticity research of the Agricultural Water Demand price of the Huanghe Valley, used the method of dose economics. Calculate the Price Elasticity of Agricultural Water Demand in Different Irrigation Area of the Huanghe Valley. It shows that there are obviously Correlation between water price and water demand and Demand-price Elasticity.

The study on price elasticity of agricultural water demand were made earlier in other countries. It is generally thought that price elasticity of agricultural water demand is higher than of industry and domestic water use. The price elasticity of agricultural water is -0.5~-1.4, some study even indicated that is -3.0 in many developed countries. In some developing countries, because of low water price, price elasticity of agricultural water demand has less effect on water conservation. Agricultural water demand can be decreased largely by raising water price appropriately [5].

3 Model of Price Elasticity of Agricultural Water Demand

Demand elasticity is a conception that was used to represent the reflection degree of the demand (dependent variable), while the factors (independent variable) that affect the change of demand [6]. The price elasticity of water demand reflects the reflection degree of water demand to change of water price. The water price changes one percent, the water consumption will change for several percents.

The following formula is used to calculate the price elasticity of water demand:

$$E = (\Delta Q / Q) / (\Delta P / P) = (\Delta Q / \Delta P) \times (P / Q) \tag{1}$$

Treat formula (1) with mathematical transformation and integration we can get formula (2):

$$Q = k \times P^{E} \tag{2}$$

Where P is water price, yuan/ hm^2, Q is water demand, m^3/hm^2, k is random variable, E is price elasticity of water demand.

The formula (3) was get by logarithm of the formula (3) both sides:

$$\ln Q = E_0 + E \ln P \tag{3}$$

Where E_0 is random variable, the other symbols are same to above symbols.

The above formula is the double logarithms model which is used to calculate the elasticity of water price. In the formula, these parameters have specified economical significances which are elasticity of price and are same in every point on the demand curve. Agricultural water demand is impacted not only by water price, but also by rainfall, planting structure and water saving level and so on [4]. In Chahayang irrigation area, the variation of planting structure and water saving level were no significant difference. So some factors that had a little changed or lack statistical data, weren't merged to random variable. The following formula was the relationship between water demand and water price and rainfall:

$$\ln Q = E_0 + E_1 \ln P + \mathrm{E}_2 \ln \mathrm{D} + \mu \tag{4}$$

Where Q is agricultural water demand, m^3/hm^2, E_1 is price elasticity of agricultural water demand, E_2 is rainfall elasticity of agricultural water demand, D is rainfall, mm, P is water price, yuan/h m^2, μ is random variable.

4 Application of the Elasticity Model of Agricultural Water Demand

4.1 The Elasticity Analysis of Agricultural Water Demand of Chahayang

Chahayang is one of the four biggest irrigation areas in northeast of china, which locates Gannan county in Heilongjiang province and the right-bank of Nuomin river downstream. It is composed of Chahayang farm and part of Gannan county. The total area of Chahayang irrigation area is 655 thousand mou, among it there is 485 thousand mou of paddy field area. Because of ageing and out-of -repair of the hydraulic engineering and the imperfect metering facility of Chahayang irrigation area, agricultural water charge is collected by mou. The per mou water charge is 20 yuan. Although agricultural water price don't change, in fact it is less because of the influence of commodity price. Agricultural water price was converted by index of the rural commodity retail price. These dates of agricultural water price and water demand were show in table1. In table1, these dates of rainfall and water demand were obtained with field investigation, and the dates of water price were obtained by converting initial water price. Other dates, i.e. index of the rural commodity retail price, were acquired by statistical yearbook of Heilongjiang.

Table 1 Basic Data of Chahayang Irrigation Area

Year	Rural commodity retail price index	Conversion factor	Water price (yuan/hm^2)	Water demand (m^3/hm^2)	Rainfall (mm)
1985	110	1	300	15516.43	298.7
1986	107.5	0.93	279	13764.73	370.5
1987	106.6	0.87	261	15022	296.4
1988	116.1	0.75	225	13061	446.6
1989	114.6	0.66	198	16360.26	505.5
1990	106.3	0.62	186	18396.43	337.4
1991	105.3	0.59	177	14653.53	479.9
1992	105.9	0.55	165	14685.38	234.9
1993	113.7	0.49	147	17230.05	640.3
1994	121.3	0.4	120	19807.4	444.8
1995	116.2	0.35	105	21781.53	248.2
1996	105.8	0.33	99	22913.52	338.1
1997	103.8	0.31	93	22005.32	290.8
1998	99.7	0.32	96	17951.87	805.7
1999	96.3	0.33	99	22696.77	275.1
2000	97.2	0.34	102	21312.91	204.3
2001	100.4	0.34	102	20222.98	271.5
2002	99.5	0.34	102	22479.03	312.8
2003	101.2	0.33	99	18603.14	484.2
2004	105.2	0.32	96	34787.75	264.3

The double logarithm model (4) was used to compute the elasticity coefficient of agricultural water demand. SPSS software was used to carry out regression analysis. After the above, the following elasticity model of agricultural water demand of Chahayang irrigation area was selected for further estimations:

$$\ln Q = 13.028 - 0.428 \ln P - 0.184 \ln D \tag{5}$$

$$\mathrm{R} = 0.831 \qquad R^2 = 0.69$$

The regression formula and regression coefficients were tested for significance in the above model. As shown in equation (5), in Chahayang irrigation area, the price elasticity coefficient of agricultural water demand is -0.428, and the rainfall elasticity coefficient of agricultural water demand is -0.184 which is lower. Pei Yuansheng etc. discovered in price elasticity of agricultural water demand of six irrigation areas in china that rainfall was included in the above model in just one irrigation area. Although rainfall relates to agricultural water demand, come reasons lead to the performance of rainfall

is not remarkable. Rainfall has no significant effect on the agricultural water demand in small rainfall areas, but it is just on the contrary in larger rainfall areas.

Compared with the water price elasticity of other irrigation areas, it is lower in Chahayang irrigation area. The main reasons are lower water price and not metering water charge, which cause water waste.

4.2 Adjustment of Agricultural Water Price and Analysis of Variation of Water Use

Base on the above model, the variation of water use of Chahayang irrigation area was analyzed quantitatively by hypothesis of different water price adjustment schemes. In 1995, the cost of water resources was 36.84 yuan per mou, equated to 579.6 yuan per ha. We suppose that rainfall of Chahayang irrigation area isn't variable and the annual average rainfall is 377.5mm. By above supposition, when agricultural water price are 70% and 100% of water cost, the quantity of water demand was calculated in table 2:

Table 2 Water Demand of Different Water Price of Chahayang Irrigation Area Unit: (m^3/hm^2)

Water demand of present water price	Water demand of 70% of water cost	Water demand of 100% of water cost
13293.15	11922.64	10234.91

As shown in table 2, where the water demand calculation are presented, the quantity of water demand will decline from 13293.15 m^3/hm^2 to 11922.64 m^3/hm^2 or 10234.91m^3/hm^2 when agricultural water price rises to 70% or 100% of water cost. That is equivalent to the quantity of water demand will decline 10.03% or 23%. The result shows the raising of water price has evident inhibition effect on water demand. At a lower water price and under farmers' bearing capacity, raising the agriculture water price appropriately is favor of improving the utilization efficiency of water resources and achieving the purpose of water saving.

5 Several Proposals on Water Price Reform of Shanxi Province Chahayang irrigation area

Agricultural water price reform relates to the development of water-saving agriculture. According to some problems, i.e. low agricultural water price and measurement on water used, several suggestions are putted forward for agricultural water price reform.

(1) Establishing and implement the formoulation of water price mechanism: a) The scientific mechanisms of water cost accounting and constraint must be established and perfected, it will make the water price reasonable and scientific. b) The water price is different in different seasons, so price difference will be enlarging.

(2) Reform the measurement of water charge. Agricultural water charge of Chahayang irrigation area is collected by mou .With the development of the productive force and optimizing allocation of water resources, this metering method of agricultural water price has already not been suitable for development of irrigation area and is disadvantageous to carrying out saves the water use and enhances the irrigation water efficiency. Carrying out gauge management for irrigation water intake is not only helpful to improve management level of water management unit, saving water consciousness of farmers and reduce water supply cost, but also helpful to Improve the efficiency of irrigation water efficiency and realize water-saving in irrigation area.

(3) Suitably enhance the water price and set up benefits compensation mechanism. Ma Xiaoyi and Zhao Wenju have put forwarded benefits compensation mechanism. These means, i.e. raising the agriculture water price, governmental direct subsidy to farmers and reducing subsidy to water supply, will be impetus on water saving agriculture development and the optimal allocation of water resources. Meanwhile, the enthusiasm of farmers and water supply departments will be mobilized. Raising the agriculture water price can play a role in saving water. If we only consider to the high-efficiency water use, but not to the farmers' bearing capacity, it isn't sensible. When the country gives the subsidy and adjust water price to cost price, farmers' benefit is not only damaged, but also the water supply department acquire best profit. Consequently it will be a management of win-win.

6 Conclusions

(1) By analyzing the influencing factors of agricultural water use and model for price elasticity of agricultural water demand, the model for price elasticity of agricultural water demand was established. In elastic model, agricultural water price and water demand were studied quantitatively. The results indicated that distinct correlation could be found between agricultural water price and water demand, and between rainfall and agricultural water demand as well.

(2) The results indicated that when the agricultural water price rises to 70% and 100% of water supply cost, the water demand will drop 10.03% and 23%, and that agricultural water price has obvious suppression effect to water use.

(3) The price elasticity of agricultural water use of Chahayang is -0.428, and is less than of some developed countries whose are -0.5~ -1.4. The water price of Chahayang is less than other areas, which can't effect on water-saving and sufficiently utilizing water resource. Therefore, to alleviate the contradiction between supply and demand of water, and to ensure reasonable use of water resource, the agricultural water price should be reasonably adjusted.

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