Journal of Software Engineering

ISSN 1819-4311

Academic
Journals Inc.

www.academicjournals.com

Journal of Software Engineering 8 (4): 287-303, 2014
ISSN 1819-4311 / DOI: 10.3923/jse.2014.287.303

Computational Evaluation the Impacting Factors of Urban Residential Water Price and Strategies Suggested to Water Pricing in Inland Area: An Empirical Study from Fuyang City

[1]Ke-Rong Zhang and [2]Wu-Yi Liu
[1]School of Economics and Management,
[2]Department of Science and Technology, Fuyang Normal College, Fuyang, 236037, China

Corresponding Author: Ke-Rong Zhang, School of Economics and Management, Fuyang Normal College, China Tel: +86-558-2596562 Fax: +86-558-2596561

ABSTRACT

The pricing of residential water and its supply, especially in water-deficient inland area, are very crucial and urgent for urban people's living. Fuyang city is a typical inland metropolis being shortage of water resources in China. In order to evaluate the determinants and impacting factors of water pricing, an empirical study was carried out using multivariate regression model to analyze the correlations among residential water price and urban disposable income and water consumption. It was found that the current urban water price is negatively and significantly correlated with the urban per capita disposable income and average water consumption. Confronted with the current increasingly scarce situation of urban water resources and difficulties encountered in the pricing of residential water, some counter measures and suggestions were eventually put forward in order to allocate the urban water resources reasonably in Fuyang city.

Key words: Water pricing, water deficiency, Fuyang city, impacting factor, multivariate regression model

INTRODUCTION

Although, the Earth's renewable fresh water resources are finite, fresh water estimated availability for 2050 is estimated to be 4380 m^3 per person per year. The value of water is hard to be priced since water is one of the world wide natural resources shared by global people. The concept "water pricing" is often referred as the processing cost of water resources to be used in irrigation, residential consumption and industry. Up to date, the water pricing mechanisms are generally not very effective in redistributing income but it may be in a government's interest to increase water available for certain sectors or citizens. The water cost or price is usually defined as the valuation in monetary units of the environmental impacts for water resources and related ecosystems caused by various socio-economic activities. The issues of economic valuation of environmental impacts do not have a direct and clear approach and that is why different estimation methodologies with corresponding restrictions have been proposed. It should be noted that water price was usually made based on the principle of total cost recovery including environmental and resource cost. Thus water price should reflect the total cost recovery in any case so as to serve three main objectives or roles; use efficiency, resource sustainability and social equity or justice. However, since the calculation of the marginal cost of water resources is not feasible, the water pricing approach is commonly based on the average estimation of total cost. As modern scientific research demonstrates, an inefficient water pricing leads to the deterioration of water scarcity which will cause a drastic increase in prices in the long term (Bithas, 2008). Meanwhile, an inefficient water pricing that under estimates future demand would jeo-pardize the goal of sustainable management, mainly for securing the amounts of water needed for the smooth functioning of ecosystems.

In an era of fixed supply and general scarcity of water resources, the use of economic instruments to manage demands for water consumption has increasingly been promoted by international organizations and scientists such as United Nations and World Bank. Berbel and Gomez-Limon (2000) developed the impact of water-pricing policy in Spain based on an analysis of three irrigated areas using linear programming model. Smith and Wang (2008) analyzed and regarded conservation oriented rates as the best new sources of urban water during drought. Chambouleyron (2004) made the comparison of efficiencies between optimal pricing and uniform pricing and found that the efficiency of marginal cost pricing was better than that of average cost pricing in allocation of resources. Gomez-Limon and Riesgo (2004) also analyzed the irrigation water pricing differential impacts on irrigated farms in European countries using Multi-Attribute Utility Theory and mathematical programming models. Grafton and Kompas (2007) studied the water pricing case of Sydney and deduced that the water pricing in Australia was very hard without a fundamental change in national water policy (both pricing and supply aspects). Ruijs *et al.* (2008) reviewed and evaluated the welfare and distribution effects of water pricing policies in the Metropolitan Region of São Paulo. Zhao and Chen (2008) put forward the fuzzy model and its application for pricing urban water resources. In their study, fuzzy model is applied in Jinan city for evaluating its validity. Wheeler *et al.* (2008) analyzed the price elasticity of water allocations demand and supply of water allocations between 2001-2007 in the Goulburn-Murray Irrigation District of Australia. They found the price elasticity of demand for water allocations appears highly elastic with the price elasticity strongly influenced by the season and drought based on bid prices while the price elasticity of supply for water allocations was elastic too. Using actual prices paid, they deduced that water demand was negatively related to price and was inelastic and appears to be most influenced by demand the previous month, drought and seasonality factors. Cai and Liu (2011) focused on the quasi-public goods of rural drinking water. Rinaudo *et al.* (2012) simulated and evaluated the impact of pricing policies on residential water demand in Southern France. Their study indicated the trade-offs should be made between the search for environmental effectiveness, cost recovery and equity when implementing complex water-pricing structures such as block rates or seasonal water pricing. Veettil *et al.* (2013) made an empirical estimation of the efficiency of irrigation water by stochastic Data Envelopment Analysis (DEA) in the Krishna river basin, India. Beecher and Kalmbach (2013) studied the structure, regulation and pricing of water to infer the context of rising costs and prices and growing concerns about accountability and sustainability in the Great Lakes region, America. Binet *et al.* (2013) investigated the price of drinking water perceived by households faced with an increasing, multi-step pricing scheme, using data from a household survey carried out in the French overseas territory of Réunion. Their study suggested that Réunion households underestimated the price of water and thus consume more than what was economically rational. Rivers and Groves (2013) evaluated the welfare impact of self-supplied water pricing in Canada by means of a computable general equilibrium assessment. Martins *et al.* (2013) reviewed and evaluated the impact of the water price regulation of Portuguese tariff recommendations.

Following the conviction that economic and pricing approaches are an essential addition to conventional command-and-control environmental regulation, China has gradually increased attention, research and experiments on the application of economic instruments in urban water management over the past two decades. Although, China is a country with substantial water resources, the regional distribution of water resources is highly unequal. Therefore, it is a general understanding that China is short of water. In the last two decades, the average amount of water per person in China is only 2300-2400 m^3 per year, about one quarter of the world average (Falkenmark *et al.*, 1989; Shi and Xu, 2001). In China, current water availability in the northern is almost 25% below the internationally accepted water scarcity threshold of 1000 cubic metres per person while water availability in the southern is relatively abundant (Shalizi, 2006). The water resources available for agricultural production in China are rapidly declining due to increased water demand for industrial use and household consumption. The use of water in agriculture as a share of total water use has steadily declined from around 80% in the 1980 to 61.3% in year 2011 (Shalizi, 2006; NBSC, 2012).

Many scholars are currently engaged in the study of residential water supply and its pricing (or price) in China. Zhang and Brown (2005) reported the empirical study on urban residential water use and consumption patterns and household capacity and willingness to respond to water conservation policy in Beijing and Tianjin, China based on a multivariate regression model analysis. He *et al.* (2007) proposed a dynamic computable general equilibrium model based on Chinese national water resource input holding output table to calculate the shadow price of water resource. Webber *et al.* (2008) overlooked and evaluated the pricing status of Chinese irrigation water. Chen and Yang (2009) studied the residential water demand model under block rate pricing in Beijing, China. In their study, the residential water is classified by the volume of water usage based on economic rules and block water is considered as different kinds of goods. Zhong and Mol (2010) evaluated the impact of Chinese water price reforms on policy-making and its implementation. They suggested that Chinese style ecological modernization should pay more attention to the institutional dimensions of natural resource pricing policies, if it is to profit from the theoretical advantages of economic approaches in urban water management. Chen and Hsu (2010) estimated the potential market price and optimal price for the water transfer among sectors in the Northern Taiwan region. Chiueh (2012) also estimated the demand function for the transferring agricultural water to industrial water during non-drought period covering from January 1998 to December 2008 in Taiwan. They found that the demand for transfer of agricultural water into industrial water is non-elastic. Chen *et al.* (2013) analyzed the pricing and water resource allocation scheme for the South-to-North Water Diversion Project in China. Mamitimin *et al.* (2014) studied the farmers' response to changes in water pricing practices in the Tarim Basin, China. They interviewed 128 farmers in different parts of the Basin and found that the sole increase of water price is not a viable option and an integrated approach is necessary, in which creation of awareness and improving agronomic skills of farmers play a key role to overcome the tight water situation and realize a more efficient usage of water. Zhang *et al.* (2014) reported a case study and evaluated the output market development affect irrigation water institutions in northern China. They found that market water trade is virtually absent and reciprocal water use arrangements (water swaps) have emerged at a limited scale.

The international community has become progressively aware of the importance of access to safe and sufficiency water resources in economic development. In fact, the vast majority of households, without such access, are in developing countries with difficulty to finance water supply and treatment operations. Investments in the water industry are typically long-term, due to large infrastructure costs associated with redesigning or building water networks. The increasing water demand is inconsistent with the dwindling water supply in the urban areas of China. Presently, there seems to be a wide agreement among natural resource economists that the optimal price for running water while waste water services should be some versions of marginal cost pricing. Marginal cost pricing has been widely endorsed by Governments, Water Authorities and Companies around the world. However, the urban water supply situation in Fuyang city is deteriorating and the urban population continually adjusts to the worsening situation. Many people only have water in their pipes a few hours per day. Households who can afford it drill their own wells and draw groundwater into overhead storage tanks. They increasingly buy bottled water or treat their drinking water. They spend scarce resources on medical care for water-borne diseases that result from groundwater infiltration into the piped distribution system. In most urban areas, residential communities and their landscapes represent a majority of water use and commodities demand in a municipality. Fuyang city is also a metropolis with relatively inadequate water resources in North of Anhui Province, China. In 2012, there were 7.63 million people in total with the tap-water usage exceeds 90% water in Fuyang city. Therefore, any changes in the water pricing will affect the urban resident lives.

Fuyang is one of the typical cities being seriously shortage of water resources in inland China. The increasingly scarce situation of urban water resources of Fuyang has restrained the development of this metropolis in North of Anhui Province, China. The extreme scarcity of water resources vs. the rapid development of economic capital of Fuyang city, becomes a serious threat to the sustainable economic and social development of Fuyang city and will induce conflicts with the urban social and economic development in contrast. Although, the water price appears superficially to be made by the water companies, it could be inferred distinctly from the present water price constitute that the water price is not the commodity price fully custom-made in Fuyang city based on the market principles. Actually, it could be deemed that the present water price constitute in itself reflects the incompletely commercial features of household water-consumption in Fuyang city. From study of home and abroad, water resources and commodities are regarded as the social public products in a considerable number of countries as well as China. In these countries, the development of water pricing has generally evolved to adopt a non-profit and/or low-profit price charging towards the public. It is the same case in Fuyang city that has regarded water resources and commodities as the public necessary products provided by the government since 1949. In the long run, how to use and protect water resources exactly and safely to provide better aquatic services in modern society? It is really hard to be contemplated and cracked in inland areas. Although, the economic indicators showed that the city's total economic output, population, GDP and other public welfare indexes have increased drastically in recent years but the water price is lower than its cost of supply in the long-term, resulting in a large loss of water companies in Fuyang city.

From the beginning of the 1990s to the 21th century, the adjustment and public crisis of water pricing had entered a period of frequent occurrence in Fuyang city. The ultimate reason is that the water price appeared to be lower than its cost of supply companies after adjustment every time. The public concerns were focused on the water pricing issues. The present study analyzed the current status of water sources, supply and demand relationships and pricing issues in Fuyang city. Moreover, the study compared the marginal cost and average cost, described the changes and its influential factors of water pricing in the last decade and worked out the reasonable theoretical water prices by means of mathematical methods in Fuyang city. Finally, the authors also put forward some constructive solutions and strategies to the water pricing issues in Fuyang city according to analyses in the present study.

MATERIALS AND METHODS

Processing of time series data (2002-2011): The residential water in Fuyang city is supplied by the Fuyang Water Service Corporation (or Fuyang Water Company). As the supply of large scale residential water is full of economic benefits and the Fuyang Water Company is supported by the government, the water industry is a natural monopoly in Fuyang city. However, the water company is under direct rule from the government to regulate the prices of residential water. Since water is a kind of natural resources, the income increase provoked by prices would increase the demand for water commodities. The monopoly of water industry is determined to be incomplete and alterable. Therefore, the higher the marginal cost of production levels declined, the sooner the water company's desired price would be reduced. These are backgrounds of the present study.

Currently, the prices of residential water were priced and enacted in Fuyang city since 2002. So far, the basic prices of residential water have been unchanged except minor modifications and the fluctuation was steady. For instance, the sewage disposal fee has been adjusted from 0.6 RMB yuan per liter adjusted to 0.7 RMB yuan per liter (i.e. average 0.65 RMB yuan per liter) in June 2005 but most of the prices of residential water have no changes since 2002. Statistical data analyzed in the present study were given in Table 1. Table 1 showed the compositions of nominal prices and actual prices of tap residential water in Fuyang city. It was also indicated the processed urban data of per capita disposable income and residential water consumption per person in Fuyang city during 2002-2011.

Analysis of the fluctuation trend and relationship between per capita disposable income and average residential water consumption in urban families: In order to figure out the correlation between the urban residential water prices (or costs) and urban per capita disposable incomes and their impacting factors in Fuyang city, a multivariate regression model was established and computed in the software package EViews 6.0 (Quantitative Micro Software Corporation, USA). The "water nominal price" (represented by Y) was selected as the dependent variable and the "average residential water consumption per person" (represented by X_1) was taken as the explanatory variable. Moreover, the "urban per capita disposable income" was also looked as the explanatory variable (represented by X_2) with the unit of measurement for X_2 converted into one thousand per unit. In the previous empirical study, Yin and Yuan (2005) and Wei *et al*. (2008) had proved that the relationship among the consumption and price of residential water and urban per capita disposable income could be expressed as:

$$Q = KP^{E1}R^{E2}$$

where, Q and P were the consumption and price of residential water while R and E1 and E2 were the people's disposable income and the elasticity coefficients of water

Table 1: Data of residential water prices, per capita disposable income and average residential water consumption in urban families abstracted from Fuyang city during 2002-2011 (Unit: RMB yuan)

	Dissection of residential water nominal prices							
Years	Basic charges	Water charges	Sewage disposal fees	Nominal prices	CPI (Consumer Price Index)	Real prices	Per capita disposable income	Average residential water consumption (m^3 per person)
2002	1.06	0.16	0.60	1.82	100.0	1.82	6041	75.22
2003	1.06	0.16	0.60	1.82	101.3	1.8	6529	64.96
2004	1.06	0.16	0.60	1.82	105.6	1.72	7096	64.53
2005	1.06	0.16	0.65	1.87	107.7	1.74	7750	56.17
2006	1.06	0.16	0.70	1.92	109.8	1.75	8817	50.69
2007	1.06	0.16	0.70	1.92	115.1	1.67	10863	49.61
2008	1.06	0.16	0.70	1.92	122.0	1.57	11727	49.25
2009	1.06	0.16	0.70	1.92	120.5	1.59	12693	45.77
2010	1.06	0.16	0.70	1.92	124.5	1.54	13981	45.56
2011	1.06	0.16	0.70	1.92	131.5	1.46	16686	45.26

Nominal price: Amount charged by the water company, Real price: Transition of nominal price adjusted for inflation. All the data are from Statistical Yearbook of Anhui Province (2003-2012; http://www.ahtjj.gov.cn/tjj/web/index.jsp) and the website publication of Fuyang Water Supply Corporation (http://www.fyzls.com/)

demand, respectively. Referring this equation and the log-linearized variables (lnY, lnX_1 and lnX_2), the multivariate regression model was established as the following (Table 2):

$$InY = \beta_0+\beta_1 \ In \ X_1+\beta_2 \ InX_2+e$$

In the model above,β_0, β_1, β_2 were the coefficients for variables. It should be noted that other impacting factors involved were looked as minor factors and ignored in the multivariate regression model above. Therefore, there might be auto correlations of variables in the modeling results when the model was used to analyze the correlation between the urban residential water prices (or costs) and per capita disposable incomes. The plots of the residual variable and correlogram analyses of

Table 2: Establishment of the multivariate regression model

Variables	Coefficient	Std. Error	t-Statistic	Prob.
lnX_1	-0.301972	0.043624	-6.922151	0.0002
lnX_2	-0.207366	0.085304	-2.430896	0.0454
C (i.e.,β_0)	4.106234	0.727869	5.641445	0.0008
R-squared	0.960598	Mean dependent var		0.508030
Adjusted R-squared	0.949340	S.D. dependent var		0.073321
S.E. of regression	0.016503	Akaike info criterion		-5.127238
Sum squared resid	0.001906	Schwarz criterion		-5.036462
Log likelihood	28.63619	Hannan-Quinn criter.		-5.226818
F-statistic	85.32828	Durbin-Watson stat		1.915951
Prob (F-statistic)	0.000012			

*Significances were measured using MacKinnon (1996) one-sided p-values, Lny: Dependent Variable, Method: Least Squares, Sample: 2002-2011, Included observations: 10

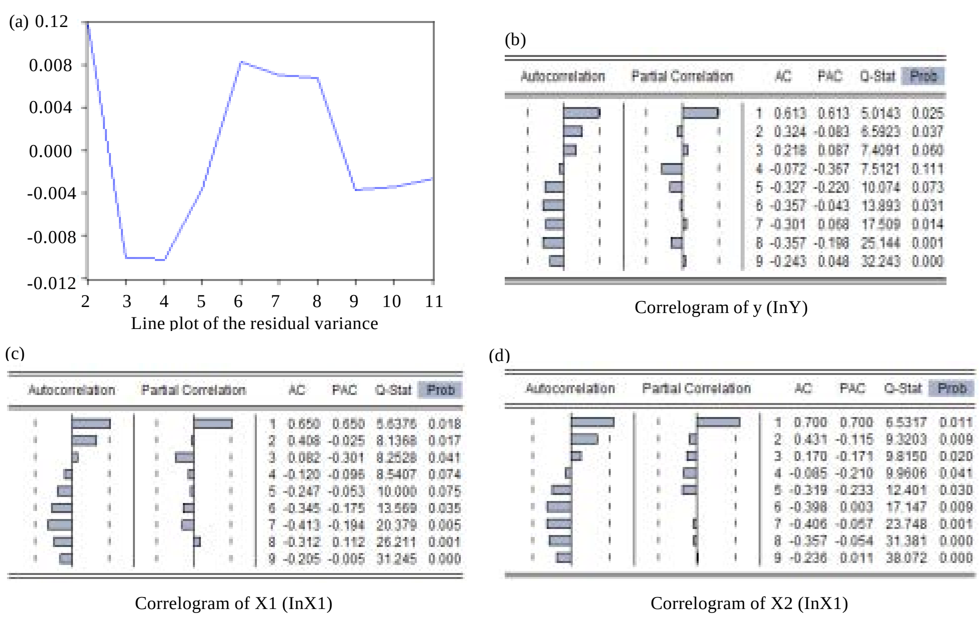

Fig. 1(a-d): Plots of the (a) Residual variable (b, c and d) Variable correlogram

Table 3: Result of stationary test for variable Y (lnY)

Null Hypothesis: D (lnY) has a unit root	t-Statistic			Prob.*
Augmented Dickey-Fuller test statistic	-4.760614			0.0381
Test critical values				
1% level	-6.292057			
5% level	-4.450425			
10% level	-3.701534			
Variables	Coefficient	Std. Error	t-Statistic	Prob.
D(lnY(-1))	-2.159562	0.453631	-4.760614	0.0176
D(lnY(-1),2)	0.763749	0.285746	2.672827	0.0755
C	0.003501	0.026331	0.132971	0.9026
@TREND (2002)	-0.008413	0.004018	-2.093918	0.1273
R-squared	0.905578	Mean dependent var	-0.001126	
Adjusted R-squared	0.811156	S.D. dependent var	0.048722	
S.E. of regression	0.021173	Akaike info criterion	-4.576637	
Sum squared resid	0.001345	Schwarz criterion	-4.607546	
Log likelihood	20.018230	Hannan-Quinn criter.	-4.958660	
F-statistic	9.590773	Durbin-Watson stat	2.519877	
Prob (F-statistic)	0.047836			

*Sgnificances were measured using MacKinnon (1996) one-sided p-values, Augmented dickey-fuller test equation, Dependent Variable: D(lnY,2), Method: Least Squares, Sample (adjusted): 2005 2011, Included observations: 7 after adjustments

variables (Y, X_1, X_2) analyzed were shown in Fig. 1. After adjustments, the correlation deduced from the model above among the urban per capita disposable income, the residential water price and consumption were shown in Table 3.

RESULTS AND DISCUSSION

Econometric tests and analysis of the time series data: The multivariate regression model was established as the following:

$$\text{InY} = 4.106234\text{-}0.301972 \text{ InX}_1\text{-}0.207366 \text{ InX}_2\text{+e}$$

Corresponding std. errors were computed as 0.727869 (for β_0), 0.043624 (for β_1) and 0.085304 (for β_2). In addition, the estimated R-squared statistics were R^2 (0.960598), $\overline{R}^2$ (0.949340), D-W-statistic (1.915951), F-statistic (85.32828) and prob (F-statistic) (0.000012).

Because the data used were all of time series, the stationary tests (ADF test equation) should be done before the correlation estimation or modeling. The results of stationary tests by ADF test equation were provided in Table 3, 4 and 5. The stationary tests revealed that there were not any unit roots in the variables lnY and $\ln X_2$ (i.e. these variables were stationary). Although, the variable $\ln X_1$ was probably non-stationary, the regression model (or equation) established above was still credible as the t-Statistic for $\ln X_1$ was -3.555069 and the probability of t-Statistic was 0.1096 in Table 4, i.e. there was a probability of 89.04% (1.00-0.1096) to take the variable $\ln X_1$ as stationary. Moreover, as the Augmented Dickey-Fuller Test Equation revealed the probability of t-Statistic for the dependent variable D(X_1, $_2$) was 0.0940 in Table 4, the variable $\ln X_1$ was more likely stationary. Therefore, the data were suitable to be applied and analyzed in the regression models and there should be no spurious regression.

Table 4: Rsult of stationary test for variable X_1 ($\ln X_1$)

Null Hypothesis: D ($\ln X_1$) has a unit root	t-Statistic			Prob.*
Augmented Dickey-Fuller test statistic	-3.555069			0.1096
Test critical values				
1% level	-5.835186			
5% level	-4.246503			
10% level	-3.590496			
Variables	Coefficient	Std. Error	t-Statistic	Prob.
D($\ln X_1$(-1))	-0.995489	0.482409	-2.063579	0.094000
C	0.089628	0.069871	1.282765	0.255800
@TREND (2002)	0.004943	0.008925	0.553890	0.603500
R-squared	0.466891	Mean dependent var		0.012398
Adjusted R-squared	0.253647	S.D. dependent var		0.066607
S.E. of regression	0.057543	Akaike info criterion		-2.592589
Sum squared resid	0.016556	Schwarz criterion		-2.562798
Log likelihood	13.370350	Hannan-Quinn criter.		-2.793514
F-statistic	2.189471	Durbin-Watson stat		1.905944
Prob (F-statistic)	0.207511			

Sgnificances were measured using MacKinnon (1996) one-sided p-values, Augmented Dickey-Fuller Test Equation, Dependent Variable: D($\ln X_1$,2), Method: Least Squares, Sample (adjusted): 2004 2011, Included observations: 8 after adjustments

Table 5: Result of stationary test for variable X_2 ($\ln X_2$)

Null Hypothesis: D ($\ln X_2$) has a unit root	t-Statistic			Prob.*
Augmented Dickey-Fuller test statistic	-4.496595			0.0486
Test critical values				
1% level	-6.292057			
5% level	-4.450425			
10% level	-3.701534			
Variables	Coefficient	Std. Error	t-Statistic	Prob.
D($\ln X_2$ (-1))	-2.066696	0.459614	-4.496595	0.0205
D($\ln X_2$ (-1),2)	0.526501	0.256231	2.054786	0.1322
C	-0.296113	0.066041	-4.483749	0.0207
@TREND (2002)	0.030117	0.007267	4.144406	0.0255
R-squared	0.924454	Mean dependent var		5.00E-06
Adjusted R-squared	0.848908	S.D. dependent var		0.075955
S.E. of regression	0.029524	Akaike info criterion		-3.911664
Sum squared resid	0.002615	Schwarz criterion		-3.942573
Log likelihood	17.690830	Hannan-Quinn criter.		-4.293688
F-statistic	12.237010	Durbin-Watson stat		2.049413
Prob (F-statistic)	0.034440			

Significances were measured using MacKinnon (1996) one-sided p-values, Augmented Dickey-Fuller Test Equation, Dependent Variable: D($\ln X_2$,2), Method: Least Squares, Sample (adjusted): 2005 2011 Included observations: 7 after adjustments

Meanwhile, a VAR (Vector Auto-Regression) equation was also established to model the correlation among $\ln Y$, $\ln X_1$ and $\ln X_2$ and to estimate the impacts of urban residential water consumption ($\ln X_1$) and disposable income ($\ln X_2$) on the water nominal price ($\ln Y$) with the multivariate regression model as the following:

$$\ln Y = -2.07287322246*\vartriangle(1)\ln Y^{-}0.0392210152404*\vartriangle(2)\ln Y-0.615252287591*\vartriangle(1)\ln X_1{}^{-}0.3681490269*\vartriangle(2)\ln X_1-0.855978996407*\vartriangle(1)\ln X_2+0.0788731709685*\vartriangle(2)\ln X_2+13.6266062439$$

The next steps were to carry out the co-integration tests and establish the long-run equilibrium equation of correlation between lnY and lnX_2, since there was only a probability of 89.04% to take the variable lnX_1 as stationary. Then, a series of co-integration tests (Granger Causality tests) were made and the co-integration regression of these variables was done too (Table 6 and 7). It could be seen from Table 7 that lnY and lnX_2 reciprocal causation variables while lnX_1 was unlikely to be the dependent variable of lnY and lnX_2. The correlation relationships were remodeled as the following:

$$InY = 0.342887\ InX_2\text{-}0.859117\text{-}\varepsilon$$

Moreover, the stationary test for the residual variable (μ_t) of the co-integration regression model for the variables lnY and lnX_2 was positive too (Table 8), i.e., the residual variable (μ_t) was stationary with a probability of 96.67% (1.00-0.0433) and there was no unit root in this variable (μ_t). This result proved to be a good support to long-run equilibrium equation of correlation between the variables lnY (the residential water price) and lnX_2 (the urban per capita disposable income). Further more, the multivariate regression model established was credible. There was little or no autocorrelation in the residual variable deduced in the multivariate regression model above (Table 8).

Table 6: Co-integration regression of Y (lnY) and X_2 (lnX_2)

Variables	Coefficient	Std. Error	t-Statistic	Prob.
lnX_2	0.342887	0.081089	4.228522	0.002900
C	-0.859117	0.323604	-2.654835	0.029000
R-squared	0.690886	Mean dependent var		0.508030
Adjusted R-squared	0.652246	S.D. dependent var		0.073321
S.E. of regression	0.043238	Akaike info criterion		-3.267340
Sum squared resid	0.014956	Schwarz criterion		-3.206823
Log likelihood	18.336700	Hannan-Quinn criter.		-3.333727
F-statistic	17.880400	Durbin-Watson stat		1.243609
Prob (F-statistic)	0.002882			

*Significances were measured using MacKinnon (1996) one-sided p-values, Dependent Variable: lnY, Method: Least Squares, Sample: 2002 2011, Included observations: 10

Table 7: Result of stationary test for the residual (E)

Excluded	Chi-sq	df	Prob.
Dependent variable: Y			
X_1	8.021692	2	0.0181
X_2	4.169479	2	0.1243
All	12.169830	4	0.0161
Dependent variable: X_1			
Y	0.195553	2	0.9069
X_2	0.558627	2	0.7563
All	1.205587	4	0.8772
Dependent variable: X_2			
Y	71.570560	2	0.0000
X_1	131.640100	2	0.0000
All	145.987700	4	0.0000

Table 8: Result of co-integration tests (Granger Causality tests)

Null Hypothesis: D(E) has a unit root	t-Statistic			Prob.*
Augmented Dickey-Fuller test statistic	-4.633595			0.0433
Test critical values				
1% level	-6.292057			
5% level	-4.450425			
10% level	-3.701534			
Variables	Coefficient	Std. Error	t-Statistic	Prob.
D(E(-1))	-2.126285	0.458885	-4.633595	0.0189
D(E(-1),2)	0.679428	0.278279	2.441539	0.0924
C	0.109719	0.039186	2.799969	0.0679
@TREND (2002)	-0.019088	0.006215	-3.071452	0.0545
R-squared	0.909149	Mean dependent var		-0.001128
Adjusted R-squared	0.818298	S.D. dependent var		0.073178
S.E. of regression	0.031193	Akaike info criterion		-3.801664
Sum squared resid	0.002919	Schwarz criterion		-3.832572
Log likelihood	17.305820	Hannan-Quinn criter.		-4.183687
F-statistic	10.007040	Durbin-Watson stat		2.322834
Prob (F-statistic)	0.045200			

*Significances were measured using MacKinnon (1996) one-sided p-values, Augmented Dickey-Fuller Test Equation, Dependent Variable: D(E,2), Method: Least Squares, Sample (adjusted): 2005 2011,Included observations: 7 after adjustments

From Table 4 and 5, the test results showed that the variables Y (lnY), X_1 (lnX_1) and X_2 (lnX_2) were almost the stationary data of time series. In other words, there might be a kind of stationary linear regression (or correlation) among these variables with the time series of data. Moreover, from Table 8, the result of stationary test for the residual variable was also positive (i.e., non-significant for the null hypothesis), with which it could be deduced that the multivariate regression model inferred in Table 6 was pronounced and suitable for subsequent analysis. In the deduced model, the statistics of R-squared and adjusted R-squared were 0.960598 and 0.949340 , respectively while F-statistic was 85.32828 and the probability for F-statistic was 0.000012 (very significant). These statistics showed the regression (correlation) among the three variables was strong. Moreover, the Durbin-Watson statistic was 1.915951 which suggested that there was little or no autocorrelation in the residual variable deduced from the multivariate regression model.

Take together, the Durbin-Watson statistics for Table 3-7 (i.e., 2.519877, 1.905944, 2.049413, 1.915951, 1.974195) were all significant or very significant (it should be noted that the Durbin-Watson statistic thresholds of significant levels are 1.57 for 5% and 2.43 for 1%) and thus there were no autocorrelations of variables in the whole modeling process. There were no unit roots existing in these three variables and the residual variable inferred from the multivariate regression model (Table 6). Therefore, there was a linear correlation among these variables and the model in Table 6 was exact. It showed that the variables X_1 (average residential water consumption per person) and X_2 (urban per capita disposable income) were significantly correlated with the variable Y (residential water price) in the long time. However, the regression coefficients showed that the variables X_1 and X_2 were negatively correlated with the variable Y in the model. Both the regression model and the trend of fluctuations in these three variables told us that X_1 (average residential water consumption per person) and X_2 (urban per capita disposable income) had much significant impacts on the pricing of urban residential water in the market of Fuyang city. From the latter regression model, it was seen that the variable X_2 was positively correlated with the variable Y which meant urban per capita disposable income level had a large significant impact on the pricing of urban residential water. The model could be used to infer the further correlations among these variables with enlarged water price data in Fuyang city.

Water pricing has not reflected the producing cost of residential water: The residential water price in Fuyang Water Corporation was made to obtain a basic water processing fee according to the company's financial statements in 2002 (http://www.fyzls.com/). It should be pointed out that the residential water price was also controlled by the government based on the formulation files of Fuyang Municipality. As we can see, although, the water producing cost and processing fee and other fees were all changed or increased over time with data from Table 1 and 8, the basic water processing fee and water price have few changes during the last decade. This led to losses of the water company. Table 9 showed the data of profit and cost of residential water production provided by the Fuyang Water Corporation in 2011.

Difficulties encountered in the pricing of residential water in fuyang city: Although, residential water industry was liable to produce monopoly enterprises in many countries and regions, the Fuyang Water Corporation was ruled and regulated by the government of Fuyang city. According to the law, i.e., "Water supply and use management rules in Fuyang city", the pricing and supply of residential water should be based on the basic water processing fee, not on the goal of profit maximization. From the law, the social welfare of people was maximized but the profit of water supplying corporation were not guaranteed. Thus, the supply and usage of water resources were not uniform distribution or allocation. These would lead to unreasonable pricing, inefficient usage and much waste of water resources. In addition, since water is a kind of natural resources, the Fuyang Water Corporation has no right to adjust or increase the price of water unless the government is in favor of changing water price. However, each price adjustment of residential water needs open hearings and discussions before being submitted to the Fuyang Municipality for review. Though reasonable water pricing can be done in theory but it is unfeasible in practice and will encounter many difficulties and problems. Any of these issues could lead to unreasonable pricing and allocation of water resources, in which the welfare losses would eventually result. In addition, water resources share similarities with both renewable and non-renewable resources, the effective way of making use of surface water is to allocate a renewable supply among competing users. For groundwater, withdrawing water now affects the resource available to future generations depending on the rate of recharge; thus, allocation of groundwater over time is most important to be considered (Johansson *et al*., 2002).

Playing an important role in water demand, residential water pricing typically assumes two forms, uniform marginal price and block prices. However, the negative economic externalities and marginal cost caused by the production of residential water using groundwater could not be deduced. As an inland enterprise, the industry of Fuyang Water Corporation is based on the exploitation of groundwater, not the surface water, to produce and supply residential water. The exploitation of groundwater will develop negative externalities, so there is a market challenge and

Table 9: Profit and cost of residential water in Fuyang Water Corporation in 2011

Project	Water production (Ten thousand tons)	Cost per ton of water (RMB yuan)	Profit (RMB yuan)	Total profit (RMB yuan)
Factory No.				
1	1862	0.893	1.58	-428.89
2	694	1.241	-430.47	

Data was provided by Fuyang Water Corporation in the website of Fuyang Public Information Network (http://www.xxgk.fy.gov.cn/DocHtml/723)

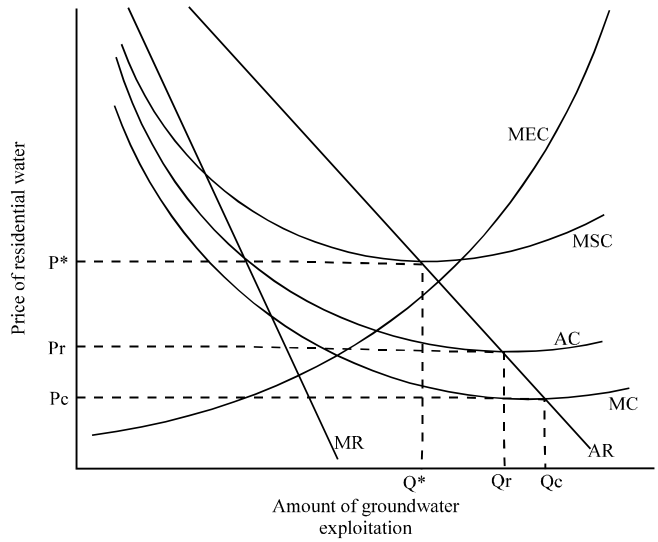

Fig. 2: The external marginal costs of groundwater exploitation

possible failure. This would make the social marginal external costs of residential water are not in the compensation of water price changes. The marginal external costs generated by the exploitation of groundwater rises as the amount of water exploitation increase while the ecological environment will be also significant affected. Therefore, the exploitation of groundwater should be controlled and limited (Fig. 2). To meet this goal it is often necessary to provide subsidized water provision or adopt differing pricing mechanisms to account for disparate income levels (Dinar *et al.*, 1997).

In 2002, the adjustment of water prices was made by the Fuyang Municipality according to the reference average costs and marginal costs (i.e., the prices at points Pr and Pc) of the Fuyang Water Corporation. The water pricing was made in case of the government management and social demand, without considering the social costs resulting from the groundwater exploitation. In view of this case and ecological protection, the residential water price might be raised and the government should levy the Pigovian Tax on the water company. At this time, the water price should be point P* and the cost of water supply should be point Q*. Particularly, it was current reported that there have been cases of subsidence in Fuyang city. This will cause damage to the road, or even much greater ecological issues. These are all the negative externalities performance of the exploitation of groundwater. However, these negative externalities are difficult to appropriately measure and/or calculate to be shared in the amount of Pigovian taxes for the current residential water price.

Without prices on the natural resources, there is not enough to satisfy all who want to use them. Economists now recognize the scarcity of valuable resources, such as water resources. In most settings, however, market prices allocate resources and allow them to move to those users who value them the most. This market process allocates resources to their most productive uses and maximizes society's wealth. Economists also recognize that resources have multiple uses. Water, for example, may be used to generate electricity, provide wildlife habitat, produce industrial products and supply households with water for drinking, etc. Over the last few decades, progressive water scarcity has been acknowledged and a significant number of countries and regions have been experiencing water price increases. A national plan in China is needed for the conservation of water and protection of water resources and the environment, adopting proper water prices. Rapid urbanization, along with improved housing and standards of living, has transformed domestic water use in cities in China, such as Fuyang city. The residential water is naturally supplied as one of the social public services and public goods. In fact, water is also a kind of natural resources shared by the people, like oxygen. Ruled by the government, it could not be interests-driven or benefit-seeking, especially in inland areas. However, the water industry requires the water company change the prices and make the profit maximization of residential water. The utmost way is to let the market rule the water company but the crucial or critical issue is how to guarantee the improvement of the profit of water supplying enterprises and urban social welfares simultaneously, i.e., the development of residential water pricing should take into account of economic efficiency and fairness at the same time. It is really a problem of balance.

In order to improve the economic efficiency and social welfares, the alternative ways are to make segmented pricing and/or family subsidy for usage of residential water to keep social fairness. The traditional way of coping with water shortages in summer months or with high water production and treatment costs was to follow the policy of Universal Metering (UM). This policy usually recommends installing water meters in all dwellings, adopting a two-part-pricing or segmented pricing scheme with a fixed fee that proxies contributed to water capacity demand and a volumetric charge equal to marginal cost. This is an appealing approach as one should expect an important reduction in water consumption and hence in water production and treatment costs. This reduction in consumption will, in turn, reduce the probability of shortages and non-price demand rationing mechanisms such as service interruptions. Segmented pricing is a novel method of pricing depending on the amount of water used in different families. It makes the discrimination of price charging at two levels to get the rational pricing of residential water, mainly depending on the water usage of different families. When the amount of water used is relatively small, the relatively low water price was applied. However, when the amount of water used is a little over a certain amount of water supply, a higher water price will be implemented. Of course, the goal to develop segmented pricing is to reduce the basic costs of household water consumption in urban family and raise the price of the residential water usage out of range of basic cost, based on local water conditions and social fairness. In fact, the segmented pricing was planned in Fuyang city as early as 2004 for reasonable pricing of residential water. Unfortunately, the plan of segmented pricing of residential water developed in 2004, has not been carried out. In the long run, this pricing approach should be promoted and executed in the near future. In the plan files of segmented pricing in 2004, the first grade of water pricing is designed as 10 m^3 of water and the basic cost is 1.06 RMB yuan; meanwhile, the second grade is planned to be 11-15 m^3 of water and its basic cost is 1.50 RMB yuan; the third grade is 16-20 m^3 of water and the cost is 2.00 RMB yuan at the basic level while the basic cost will be changed into 2.5 RMB yuan with water usage more than 20 tons. The segmented pricing approach has many benefit aspects, for example, with water charges changed in segmentation, more and more people will receive high quality water supply and social fairness in given water consumption grades, especially for those people with low disposable income. This pricing approach can greatly improve the income of water enterprises without affecting the living standards of low-income people. Changes in residential water price could also promote the conservation of water resources or reduce the exploitation of groundwater.

Family subsidy is another feasible way of keeping the proper water pricing and social fairness and social welfare in urban water consumption. If you change the water pricing policy which can promote a more equitable society, you could improve social welfares as well. If the social largest water company wants to raise water prices for the purpose of profits with social fairness and social welfare simultaneously, they can put profits average subsidy to low water consumption families all the time. Thus, family subsidies could be regarded as the compensation for the excess household payments of less water consumption charged by the water company. This way of allocating the remaining profits of water companies could play key roles in the distribution of income, social fairness and social welfare.

CONCLUSION

Water has been taken for granted as a kind of essential public needs, resources and necessities in modern society. Urban residential water supply as one of the basic environmental infrastructures and services is one of the major causes of environmental problems among cities in the developing world and in transition economies. The present study found that there was a linear regression (or correlation) among the variables was exactly modeled while the multivariate regression model was pronounced and suitable for analysis. It showed that the variables “average residential water consumption per person” and “urban per capita disposable income” were both negatively and significantly correlated with the variable “residential water price” in the long time. However, the regression coefficients showed that the former two variables were negatively correlated with the latter variable in the regression model. Both the regression model and the trend of fluctuations in these three variables told us that the former two variables had large significant impacts on the latter variable, i.e., the pricing of urban residential water in Fuyang city.

Confronted with the current increasingly scarce situation of urban water resources and difficulties encountered in the pricing of residential water, in the present study, some suggestions and countermeasures were also recommended for residential water pricing in Fuyang city. Current practices in Fuyang city which focus only on urban districts, are not beneficial to establishing an active water market. Meanwhile, discrepancies between urban and rural, entitled and un-entitled, in service delivery will raise more equity issues. The fair and reasonable prices of residential water can promote the rational allocation of resources and social welfare in Fuyang city. Given the more limited financial resources of the government, future municipal water policy should prioritize accessibility rather than the elitism in delivering water service. Municipal water systems should be prepared for a rapid and ongoing urbanization process. Water demand management, wastewater recycling and reuse, water conservation and efficiency should lead policy in municipal water supply planning and management.

ACKNOWLEDGEMENT

We are grateful to the anonymous reviewers for their comments and suggestions. This study was supported by National Statistical Scientific Research Project (No.2013LY051) and the Fuyang Normal College Educational Programs (No. 2013JYXM24).

REFERENCES

Beecher, J.A. and J.A. Kalmbach, 2013. Structure, regulation and pricing of water in the United States: A study of the Great Lakes region. Utilities Policy, 24: 32-47.

Berbel, J. and J.A. Gomez-Limon, 2000. The impact of water-pricing policy in Spain: An analysis of three irrigated areas. Agric. Water Manage., 43: 219-238.

Binet, M.E., F. Carlevaro and M. Paul, 2013. Estimation of residential water demand with imperfect price perception. Environ. Resour. Econ. (In Press). 10.1007/s10640-013-9750-z

Bithas, K., 2008. The European policy on water use at the urban level in the context of water framework directive. Effectiveness, appropriateness and efficiency. Eur. Plan. Stud., 16: 1293-1311.

Cai, Y. and P. Liu, 2011. The pricing mechanism for safety drinking water supply in rural area. Energy Procedia, 5: 1467-1472.

Chambouleyron, A., 2004. Optimal water metering and pricing. Water Resour. Manage., 18: 305-319.

Chen, C.C. and S.H. Hsu, 2010. Estimating the potential water transfer prices using price endogenous theory. Water Resour. Manage., 24: 3237-3256.

Chen, H. and Z.F. Yang, 2009. Residential water demand model under block rate pricing: A case study of Beijing, China. Commun. Nonlinear Sci. Numer. Simulat., 12: 2462-2468.

Chen, Z., H. Wang and X. Qi, 2013. Pricing and water resource allocation scheme for the south-to-north water diversion project in China. Water Resour. Manage., 27: 1457-1472.

Chiueh, Y.W., 2012. The price elasticity of transferring agricultural water to industrial water during non-drought period in Taiwan. Paddy Water Environ., 10: 41-47.

Dinar, A., M.W. Rosegrant and R. Meinzen-Dick, 1997. Water allocation mechanisms: Principles and examples. Policy Research Working Paper No. 1779, World Bank, Washington, DC., USA., June 1997.

Falkenmark, M., J. Lindquist and C. Widstrand, 1989. Macro-scale water scarcity requires micro-scale approaches. Nat. Resour. Forum, 13: 258-267.

Gomez-Limon, J.A. and L. Riesgo, 2004. Irrigation water pricing: Differential impacts on irrigated farms. Agric. Econ., 31: 47-66.

Grafton, R.Q. and T. Kompas, 2007. Pricing Sydney water. Aust. J. Agric. Resour. Econ., 51: 227-241.

He, J., X. Chen, Y. Shi and A. Li, 2007. Dynamic computable general equilibrium model and sensitivity analysis for shadow price of water resource in China. Water Resour. Manage., 21: 1517-1533.

Johansson, R.C., Y. Tsur, T.L. Roe, R. Doukkali and A. Dinar, 2002. Pricing irrigation water: A review of theory and practice. Water Policy, 4: 173-199.

MacKinnon, J.G., 1996. Numerical distribution functions for unit root and cointegration tests. J. Applied Econ., 11: 601-618.

Mamitimin, Y., T. Feike, I. Seifert and R. Doluschitz, 2014. Irrigation in the Tarim Basin, China: Farmers response to changes in water pricing practices. Environ. Earth Sci. (In Press). 10.1007/s12665-014-3245-2

Martins, R., L. Cruz and E. Barata, 2013. Water price regulation: A review of portuguese tariff recommendations. Public Organiz. Rev., 13: 197-205.

NBSC, 2012. China Statistical Yearbook 2011. National Bureau of Statistics of China, Beijing, China.

Rinaudo, J.D., N. Neverre and M. Montginoul, 2012. Simulating the impact of pricing policies on residential water demand: A Southern France case study. Water Resour. Manage., 26: 2057-2068.

Rivers, N. and S. Groves, 2013. The welfare impact of self-supplied water pricing in Canada: A computable general equilibrium assessment. Environ. Res. Econ., 55: 419-445.

Ruijs, A., A. Zimmermann and M. van den Berg, 2008. Demand and distributional effects of water pricing policies. Ecol. Econ., 66: 506-516.

Shalizi, Z., 2006. Addressing China's growing water shortages and associated social and environmental consequences. Policy Research Working Paper No. 3895, World Bank, East Asia and Pacific Region, China, April 2006.

Shi, Z. and L. Xu, 2001. Water pricing policy in tarim basin of China. Tsinghua Sci. Technol., 6: 469-474.

Smith, W.J. and Y.D. Wang, 2008. Conservation rates: The best new source of urban water during drought. Water Environ. J., 22: 100-116.

Veettil, P.C., S. Speelman and G. Van Huylenbroeck, 2013. Estimating the impact of water pricing on water use efficiency in semi-arid cropping system: An application of probabilistically constrained nonparametric efficiency analysis. Water Resour. Manage., 27: 55-73.

Webber, M., J. Barnett, B. Finlayson and M. Wang, 2008. Pricing China's irrigation water. Global Environ. Change, 18: 617-625.

Wei, L., Q. Fu and L. Chen, 2008. Elastic analysis on the water demand of urban residential of Harbin. J. Northeast Agric. Univ., 39: 34-37.

Wheeler, S., H. Bjornlund, M. Shanahan and A. Zuo, 2008. Price elasticity of water allocations demand in the Goulburn-Murray Irrigation District. Aust. J. Agric. Resour. Econ., 52: 37-55.

Yin, J.L. and R.H. Yuan, 2005. Analysis of the elasticity of nanjing domestic water demand. South-to-North Water Tromsfersomd Water Sci. Technol., 32: 46-48.

Zhang, H.H. and D.F. Brown, 2005. Understanding urban residential water use in Beijing and Tianjin, China. Habitat Int., 29: 469-491.

Zhang, L., X. Zhu, N. Heerink and X. Shi, 2014. Does output market development affect irrigation water institutions? Insights from a case study in Northern China. Agric. Water Manage., 131: 70-78.

Zhao, R. and S. Chen, 2008. Fuzzy pricing for urban water resources: Model construction and application. J. Environ. Manage, 88: 458-466.

Zhong, L. and A.P. Mol, 2010. Water price reforms in China: Policy-making and implementation. Water Resour. Manage., 24: 377-396.