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Applying CVM for Economic Valuation of Drinking Water in Iran

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Abstract

Economic valuation of water is useful in the administration and management of water. Population growth and urbanization caused municipal water demand increase in Iran. Limited water resource supply and urban water network capacity raised complexity in water resources management. Present condition suggests using economic value of water as a criterion for allocating policies and feasibility study of urban water supply projects. This study use contingent valuation method for determining economic value of drinking water in Kohkiloye & Boyerahmad province. Required data set were obtained from 177 questionnaires by applying stratified random sampling in 2011 year. From 136 investigated urban households 111 ones are willing to pay more for qualified drinking water. Also, from 41 investigated rural households only 3 ones are willing to pay more for qualified drinking water. Results indicated that economic value of drinking water is 6877 Rial per cubic meter.

Keywords:
Economic Value of Water, Willingness to Pay, Municipal Water Consumption, Contingent Valuation Method, Kohkiloye & Boyerahmad Province

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INTRODUCTION

Iran is one of the arid and semi-arid countries of the world with average precipitation of 251 mm per year. The total renewable water resources of Iran is 130 billion cubic meters, out of which 92 percentages is used for agriculture, 6 percentages for domestic use and services and 2 percentages for industrial uses (Assadollahi, 2009). Rapid population growth and low irrigation efficiency in agricultural sector of Iran have increased the demand for water resources. Therefore, rational management for water supply and demand and optimum use of the available water resources is necessary. Managing water as an economic good is an important way of achieving efficient and equitable use, and of encouraging conservation and protection of water resources. Water resources provide variety of products and services for human being include food, drinking water, hygiene, entertainment and hydropower. Water demand amount and variety increase beside water supply limitations in municipal regions cause competition among users and impose pressure on drinking water networks. Widespread network of water in cities, high cost of drinking water supply and important role of water in sustainable development raised complexity in water resource management in most cities of Iran. Water allocation and using water economic value as a criterion for allocating is one of the mentioned complexity in water resource management (Turner *et al.,* 2004). The value of water in alternative uses is important for the rational allocation of water as a scarce resource, whether by regulatory or economic means. Water economic value could be used as a proper framework for water pricing and water allocating policies. Also, benefit-cost analysis of water supply projects mainly uses water economic value for economic benefit determination. Most of development documents in Iran insist on estimating economic value of water in different uses and applying this amount as a criterion for allocating. Fourth development program of Iran noted economic value of water should be calculated in water basins. Also, in Fifth development program of Iran using water economic value for allocating and supplying water resource has been mentioned. Many studies estimate economic value of water in agriculture usage applying parametric and non-parametric methods like production function and mathematical programming (Hussain and Young, 1985, Thompson, 1988, Chakravorty and Roumasset, 1991, He and Tyner, 2004). Against irrigation water, drinking water considered as a final commodity in economical modeling and its economic value determination approach completely different from the situation in which water is a production input like in agriculture and industry (Lehtonen *et al.,* 2003). When water considered as a final commodity, contingent valuation method could properly used for its economic value determination. Many studies use CVM for estimating and calculation economic value of drinking water (Gnedenko and Gorbunova, 1998, Gnedenk *et al.,* 1999, Farlofi *et al.,* 2007, Guha, 2007).

According to the importance of economic water valuation in Kohkiloye and Boyerahmad province, present study estimated economic value of drinking water in municipal and rural districts of mentioned province based on willingness to pay of households for proper quality of drinking water. Estimated WTP for drinking water could be used in benefit-cost analysis of urban water supply projects in Kohkiloye and Boyerahmad province.

MATERIALS AND METHODS

Several approaches applied for economic valuation of water which categorize into two main groups include economic valuation of water as a production input and economic valuation of water as an economic commodity. In agriculture and industry, water used as an input and approaches like production function or mathematical programming applied for economic valuation of water. In municipal usage water treated as a final commodity and water consumers gained utility by using water. Hence, in this case approaches like contingent valuation method, choice modeling and water market transactions have been used for estimating economic value of water (Young, 2005). CVM studies are very popular among mentioned approaches used for economic valuation of drinking water, present study apply CVM for achieving to the foresaid goals.

CVM usually used as a standard and flexible tool for measuring non-use values and non-market use values of natural resources and environment (Hanemann *et al.,* 1991 and Hanemann, 1994). CVM determined individuals WTP in hypothetical scenarios (Lee, 1997). In this approach a hypothetical market for drinking water with proper quality established and some proposed price suggested to individuals for acquiring mentioned commodity. Individual's answer to the proposed prices or bids has been formed based on maximizing utility. As shown below, accepting proposed price means that utility gained by accepting is more than the utility of denying proposed price.

$$U(1, Y-A; S)+\varepsilon_1 \geq U(O, Y; S)+\varepsilon_0 \quad (1)$$

In above equation U is indirect utility, Y is individual income, A is proposed price or bid and S is social-economical characteristics. Utility difference is as below:

$$\Delta U = U(1, Y-A; S) - U(O, Y; S) + (\varepsilon_1 - \varepsilon_0) \quad (2)$$

According to the model characteristics logit or probit functional form has been used for estimating valuation function. Considering Pi as the probability of accepting proposed price (A) by individual, logit functional form could be formed as below:

$$P_1 = F_\eta(\Delta U) = \frac{1}{1+\exp(-\Delta u)} = \frac{1}{1+\exp\{-(\alpha - \beta A + \gamma Y + \theta S)\}} \quad (3)$$

In which $F_\eta(\Delta U)$ is cumulative distribution function. θ, γ and β are regression coefficients and it is expected that θ>0, γ>0 and β≤0. After estimating above logit function it is possible to calculate expected WTP using integral.

Logit regression model coefficients have been determined using maximum likelihood estimator (Lehtonen and *et al.,* 2003). Integral of $F_\eta(\Delta U)$ between 0 to infinity has been calculated based on below equation:

$$E(WTP) = \int_0^\infty F_\eta(\Delta U)dA = \int_0^\infty \left(\frac{1}{1+\exp\{-\alpha^* + \beta A\}}\right)dA \quad (4)$$

In above equation E(WTP) is expected willingness to pay and α^* is adjusted constant which is constructed as below:

$$[\alpha^* = (\alpha + \gamma Y + \theta S)] \quad (5)$$

One of the main advantages of logit estimation is that it is possible to investigate change in variables amount on the probability of accepting proposed price by individual i. The probability of bid acceptance by individual defined as below:

$$P_i = F(X_i^* \lambda) = \frac{1}{1+\exp^{X_i^* \lambda}} \quad (6)$$

In which, X_i^* is the vector of variables and λ is the vector of coefficients. In order to evaluate the effect of each variable quantity change on the probability of bid acceptance, the derivation of above equation has been calculated (Maddala, 1991):

$$\frac{\partial P_i}{\partial X_{ik}} = \frac{\exp^{X_i^* \lambda}}{(1+\exp^{X_i^* \lambda})^2} \lambda_k \quad (7)$$

This equation generates marginal effect of each variable which is very useful in policy making analysis of model results. Requested data set were obtained through a survey using questionnaires. Mainly, information like education, age, individual satisfaction of drinking water quality and quantity, monthly income and expenditure, water consumption quantity and willingness to pay for drinking water has been asked from each individual by interviewing. Present study used stratified random sampling method for determining the sample size. From 177 sample size 136 and 41 questionnaires gathered from urban and rural districts of Kohkiloye & Boyerahmad province, respectively. Explanatory variables which were used in logit model for estimating economic value of drinking water could be summarized in below table 1.

RESULTS AND DISCUSSION

Investigating sample individuals' satisfaction of drinking water quality showed that 7 percentages of rural individuals and 40 percentages of urban individuals satisfied with present condition of drinking water quality. On the other hand, 93 percentages of investigated rural individuals and 60 percentages of investigated urban

Table 1

Explanatory variables	Description
Region	Dummy variable (1= urban district, 0= rural district)
Water quality	Dummy variable (1=satisfaction from drinking water quality, 0=dissatisfaction from drinking water quality)
Water quantity	Dummy variable (1=satisfaction from drinking water quantity, 0=dissatisfaction from drinking water quantity)
Monthly income	In 1000 Rials
Monthly water consumption	In cubic meter
Family size	-
Proposed price or bid	In 1000 Rials
Family supervisor gender	Dummy variable (1=male, 0=female)
Family supervisor age	-
Family supervisor education	-

individuals dissatisfied with drinking water quality. Reasons of dissatisfaction could be summarized as kidney diseases occurrence, parasite

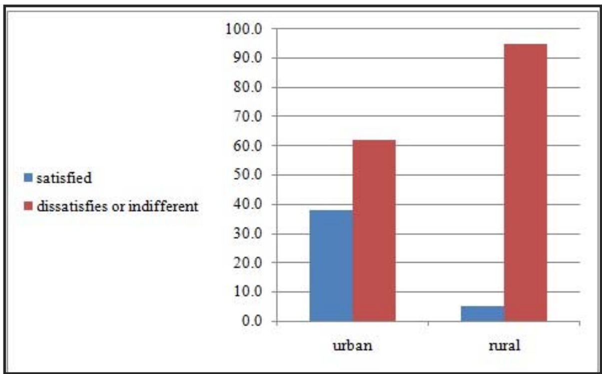

Figure 1: Comparing satisfaction level of drinking water quality in urban and rural districts (percentages).

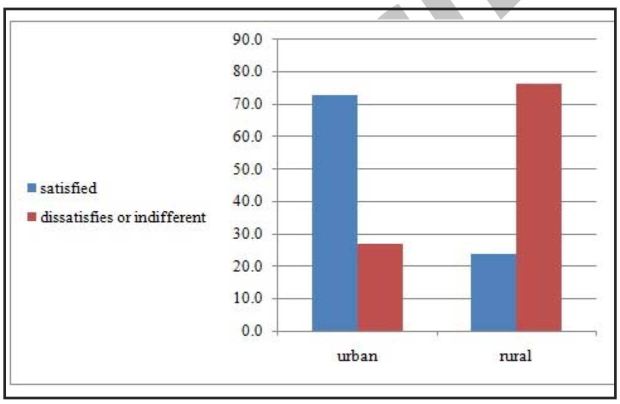

Figure 2: Comparing satisfaction level of drinking water supply in urban and rural districts (percentages).

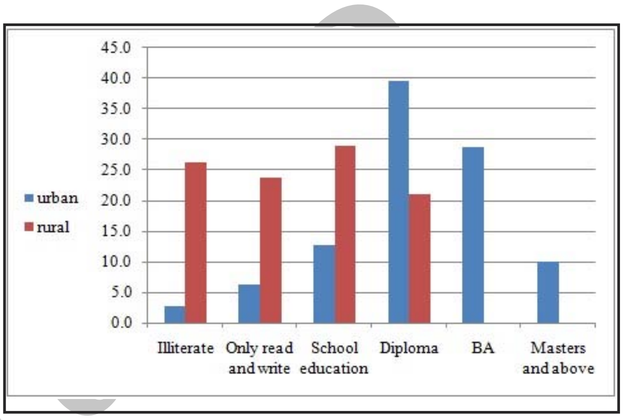

Figure 3: Comparing education level of sample individuals in urban and rural districts (percentages).

diseases occurrence and existence of pollution in rural drinking water.

Investigating sample individuals' satisfaction of drinking water quantity showed 17 percentages in rural districts and 69 percentages in urban districts satisfied by present condition of drinking water quantity or supply. Also, 83 percentages of investigated people in rural districts and 31 percentages in urban districts dissatisfied from drinking water quantity or supply. Reasons of dissatisfaction include water quantity, dissection, and network insufficient pressure. Hence, households forced to use tankers or reserve drinking water.

Investigating sample individuals' education level showed that frequency of diploma degree

Table 2: Comparing willingness to pay in urban and rural districts.

District	Description	Willing to pay more	Will not pay more
Urban districts	Frequency	111	25
	percentages	81	19
Rural districts	Frequency	38	3
	percentages	93	7

Source: research findings.

Table 3: Logit model estimation result.

Variables	Coefficients	S.D.	t-statistics	Marginal Effect
Bid	-0.107	0.042	-2.503	-0.024
Monthly income	0.00064	0.00036	1.76	0.00014
Family supervisor education	0.085	0.041	2.061	0.0192
Region	-1.113	0.679	-1.637	-0.25
Constant	1.834	0.639	2.868	-

Log of likelihood function = -86.5
Percentage of Right Predictions = 0.77
Source: Research findings.

is more in urban districts. Education level frequency of sample is shown in figure 3.

From 136 investigated urban households 111 ones are willing to pay more for qualified drinking water. Also, from 41 investigated rural households only 3 ones are willing to pay more for qualified drinking water.

After estimating different models with explanatory variables, below model select as the best estimations.

Results revealed that bid, monthly income, family supervisor education level and dummy of region variables had direct and statistically significant effects on probability of bid acceptance. Marginal effect value of monthly income variable showed that one unit increase (1000 Rials increase) in monthly income 0.0192 unit increase the probability of bid acceptance. Also, marginal effect of bid showed that 1000 Rials increase in bid amount 0.024 unit decrease the probability of bid acceptance by sample individuals. One level increase in family supervisor education 0.0192 unit increase the mentioned probability amount.

Percentages of right prediction in logit model were 77 percentages. So, 77 percentages of individuals' responses could be simulated by model. Using model coefficients, the amount of α^* calculated ($\alpha^* = 2.171$). Expected quantity of WTP for drinking water consumption equals 213187 Rials per month. Considering average drinking water consumption for each household as 31 cubic meters, value of a cubic meter drinking water equals 6877 Rials.

CONCLUSION

Results revealed that drinking water consumers were willing to pay 6877 Rials per cubic meter in Kohkiloye & Boyerahmad province. This price could be used as a good framework for allocating planning of drinking water. Also, for calculating economic benefits of new drinking water supply projects this value could be used. Applying CVM approach for economic valuation of drinking water provides good view for managers and planners about consumers' demand of drinking water.

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