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Valuation of Water and its Sensitive Analysis in Agricultural Sector A Hedonic Pricing Approach

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Abstract: Problem statement: In the recent decades water scarcity and its impacts on agricultural sectors and food security are growing concerns worldwide. Water scarcity is one the major problem facing agricultural production in Iran. In this context valuation of irrigation water can be suggest as an appropriate solution. **Approach:** This research based on utilizing hedonic pricing method for estimating effective variables on the value of agricultural lands and used a way, for obtaining the value of irrigation water in Mashhad. Sensitive analysis is also used for observation of varieties in the value of water. **Results:** Results showed that, irrigation water is the most effective and significant variable in the controversial area. Results of the sensitive analysis indicated that, by increasing discount rate, the value of water increased. Whereas by decreasing period of investment and annual consumption of water, the value of it, decreased. **Conclusion:** In the case of agricultural lands are allocated to cultivation of valuable crops, discount rate of investment would increase; and also if agricultural lands invested in quick return activities, period of investment decrease. And therefore, the value of irrigation water in m^{-3} increases. Results indicated that by decrease of aridity and so increase in water consumption, in a long run period of investment, value of irrigation water decreases.

Key words: Water, hedonic pricing model, sensitive analysis, Mashhad

INTRODUCTION

Shortage of water in Iran is one of the most important factors that restrict development of economic activities. With respect to the climatic conditions of the Iran, groundwater is the major source of crop irrigation. Especially in dry and semidry areas, agriculture depends largely on groundwater withdrawals (Daneshvar Kakhki *et al*., 2009).

Increasingly, water scarcity is described as a major challenge facing Iran, an arid and semiarid country, with an average annual precipitation (250 mm) which is less than one-third of the world average (Moghaddasi *et al*., 2009). So management of water supply and demand is very necessary and vital in recent years. Agricultural sector is the biggest user of water in Iran (more than 90%) and also wastes water more than other sectors (70%). The most important reason for wasting is the very low-cost water for irrigating farms in Iran. Cheap water is very common in the most countries. 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, have little incentive to conserve it or refrain from growing water-intensive crops. Apart from politics, a crucial factor, which equally contributes to the inefficiency of water allocation, is the apparent lack of proper pricing of agricultural water (Hrovatin and Bailey; Unnerstall, 2007).

Having appreciated the significance of water pricing, the problem now comes to another major issue, which is a prerequisite in the implementation of almost every pricing method. This is the proper valuation of water, which, as a classic non marketed resource, can seldom be assigned a justified market price, even for its commodity uses. Therefore, in most cases, an indirect, non market valuation method is employed in order to assess a reliable figure for the value of water (Young, 1996).

The present study reports the experience gained and the results obtained from the application of such a valuation technique in order to reveal the implicit value of irrigation water by the analysis of agricultural land property values. The Hedonic Price (HP) method is the specific valuation technique, which was used to disaggregate the sale price of the bundled good (i.e., land property) in order to reveal its water component (Latinopoulos *et al*., 2004). The case study presented

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herein refers to an area in plain of Mashhad that called Mashhad too.

There are a lot of studies about water and the use of HP model. Torell *et al*. (1990) compared sales of irrigated and non-irrigated lands to estimate the value of groundwater in the southern high plains in the US. Results indicate the water value component or irrigated farm sale transactions ranged from 30-60% of the farm sale prices, depending on state. Butsic and Netusil (2007) used HP to valuing water rights in Douglas County, Oregon. Aloso, Faux and Perry (1999) used HP to agricultural land sales in Malheaur County, Oregon, to reveal the implicit market price of water in irrigation. Results indicate the value of water on the least productive land irrigated is 7.7 for an Acer-foot and up to 37.5 Acer-foot^{-1} on the most productive land. Mahan *et al*. (2000) used HP to estimate the effect of proximity to wetlands on property vales in Portland. Latinopoulos *et al*. (2004) utilized HP method to reveal the implicit value of irrigation water by analyzing agricultural land values in Chalkidiki in Greece. Results showed that agricultural characteristics of land, including irrigation water availability, have a significant influence on land prices. Miranowski and Hammes (1984), used HP method for obtaining the relationship between land prices and groundwater access (both in quantity and quality terms) (Ervin and Mill, 1985; Gardner and Barrows, 1985; King and Sinden, 1988). Vural, *et al*. (2009) used HP method to study land marketing in Turkish markets.

MATERIALS AND METHODS

Method: The Hedonic Pricing Model (HPM) is based on Lancaster's characteristics theory of value (Lancaster, 1966), which states that any good can be described as a bundle of characteristics and the levels these take and that the price of the good depends on these characteristics. So it could be lead to value of non marketed characteristics of the goods.

Residential housing and land property are among the most frequently used types of such markets, in which sale price data exhibit differing but measurable environmental characteristics, like domestic water (North and Griffin, 1993) or water for irrigation. Consequently, given the hedonic price function for land properties in an area, the implicit price of water can be determined by calculating the increase in the properties' value with an extra unit of this attribute (Latinopoulos *et al*., 2004).

As the price of land is related to its quality and quantity characteristics, HP model consists of the regression of goods price on its characteristics.

Table 1: Comparing linear model with semi log one

Criterion	Value
SBC-criteria for comparing linear model with semi log one	-37.6
Ramsey test in linear model	4.3
Ramsey test in semi log model	2.8*

*: Function form is specified well

So HP will use for determining demand of goods that are function of their characteristics.

Let Y as a product (goods), so production function is:

$$Y = f(Z) \quad (1)$$

And Z is the vector of input characteristics. With assuming maximization of profit by the firm, we have:

$$\pi = pf(Z) - WX \quad (2)$$

Where:
p = The price of product
W = The vector of input prices
X = The vector of inputs

The first order condition for maximizing profit is:

$$\frac{\partial \pi}{\partial X_i} = p\sum\left[\frac{\partial f}{\partial Z_j}.\frac{\partial Z_j}{\partial X_i}\right] - W = 0 \quad (3)$$

And for every particular input, Eq. 3 is written to Eq. 4, so:

$$W_i = \sum\left[T_j.\frac{\partial Z_j}{\partial X_i}\right], T_j = p.\frac{\partial f}{\partial Z} \quad (4)$$

where, T_j is the marginal value of the jth factor. So, Eq. 4 is the hedonic pricing model.

Data- the present study used questionnaire that was addressed to a sample of farmers who were owner of lands and applied 101 parcels that are formed of 54 irrigated and 47 non-irrigated parcels in Mashhad.

Empirical model for agricultural land-According to Table 1, semi log model is better than linear model for estimating hedonic pricing model of agricultural lands. Because, negative SBC criteria and Ramsey test show that semi log model is better than the other. So semi-log form is:

$$InP = \propto + \sum_{i=1}^{6} \beta_i X_1$$

Where:
P = Land price (Rial h^{-1})

$\propto$ = A base price for agricultural land that is determined by the general characteristics of the area
X_1 = The local value of water in an hour (Rial h^{-1})
X_2 = Distance to nearest village or town (km)
X_3 = Distance to nearest main road (km)
X_4 = Altitude of the field above MSL (m)
X_5 = Local climate: 1 if pertaining climate, 0 if alpine climate
X_6 = Irrigated land: 1 if yes, 0 if no

RESULTS

Table 2 shows that intercept value is very significant and large in magnitude. It means the base value of lands and is 5971960 Rials (exp 13.3) in the area. The other variables that are statistically significant, are X_2, X_4 and X_6. X_2 is the distance of land to the nearest town that shows facility of coming and going to town. The sign of this variable shows that by decreasing distance to the town, value of land increases. X_4 is the altitude of land. The sign of this variable is opposite of previous researches. The main reason of this problem is because of farmers' though for non agricultural uses (with higher benefits) of the high lands in the future, that causes more value of the high lands. So, positive sign for this variable isn't unusual in the controversial area.

The last significant variable is irrigation water that is used for measuring the value of water in the farming area. According to Table 2, coefficient of this variable is 2.09, which shows the value of irrigated lands are 8 (exp2.09) times more than no irrigated ones.

Estimating value of irrigation water-the value of irrigation water was estimated by the land value approach in the same way with previous applications of the HP method (Faux and Perry, 1999; Torell *et al*., 1990). In this way, the average of variables, except water, is used in HP function. The value of water is obtained with the deference of A (value of irrigated land) and B (value of no irrigated land) in the following equations:

$$A = EXP\left[\sum_{i\neq I} X_i \times b_i + b_I \times 1\right] = EXP(15.62884) = 6130818$$

$$B = EXP\left[\sum_{i\neq I} X_i \times b_i + b_I \times 0\right] = EXP(13.53384) = 754521.3$$

$$C = A - B = 6130818 - 754521.3 = 5376297$$

Where:
X_i and b_i = The average values and coefficient of variables (except water)
b_I = The coefficient of water. So, the value of irrigation water is 53762970 Rials in each ha (Table 3)

Annual value of water by a suitable discount rate (benefit rate of long run bank deposit in 5 years, 16%) can be estimated. This value is 16397710 Rials in the area.

Table 4 and 5 shows the sensitive analysis in the value of water, supposing that, the above cases change. Table 4 states that, by decreasing investment period and also increasing discount rate, the value of irrigation water increases.

Table 5 indicates that by decrease of aridity and so increase in water consumption, in a long run period of investment, value of irrigation water decreases.

Table 2: Results of HP model estimation

Variable	Coefficient	t-ratio
Intercept	13.316	67.28*
Local value of water in an hour	-4.30E-06	-0.81
Distance to nearest village or town	-0.018	-4.71*
Distance to nearest main road	0.0015	0.186
Altitude of the field above MSL	7.20E-04	2.99*
Local climate	0.188	1.25
rigationir	2.09	9.34*
R^2	0.84	
F	87.95	
DW	1.48	
Heteroscedasticity	1.1 (0.3)	
Ramsey test	2.8 (0.1)	

*: Significant at 1%

Table 3: Value of irrigation water

Value of irrigated land ha^{-1}	61308180.00
Value of no irrigated land ha^{-1}	7545210.00
Value of water ha^{-1}	53762970.00
Value of irrigated land to value of no irrigated land	8.08
Annual value of water per hectare (with a discount rate)	16397710.00
Value of water m^{-3}	3326.00
Value of water m^{-3} (with a discount rate)	1014.00

Table 4: Sensitive analysis of the value of water by discount rate and period

	Discount rate (%)								
Period	5	8	10	12	16	14	20	25	30
5	76.5	83.2	86.5	92.1	101.5	96.5	111.1	123.1	136.4
10	43.1	49.6	54.1	58.9	68.9	63.5	79.2	93.1	107.4
20	26.6	33.9	38.9	44.6	56.2	50.2	68.2	84.2	100.1
30	21.6	29.6	35.3	41.2	53.6	47.5	66.8	83.3	99.8
40	19.4	27.9	33.9	40.2	53.4	46.8	66.6	83.2	99.8
50	18.2	27.2	33.6	40.1	53.3	46.6	66.5	83.2	99.8
100	16.6	26.6	33.3	39.9	53.2	46.6	66.5	83.2	99.8

Table 5: Sensitive analysis of the value of water by water consumption and period of investment

Water consumption period	Percent*								
	-20	0	20	40	60	80	100	150	300
	12930	16163	19396	22628	25861	29093	32326	40408	64652
5	126.8	101.5	84.5	72.5	63.4	56.4	50.7	40.6	25.4
10	85.7	68.5	34.3	48.9	42.8	38.1	34.3	27.4	17.1
25	68.2	68.2	45.5	39.0	34.1	30.3	27.3	21.8	13.6
30	67.4	67.4	44.9	38.5	33.7	29.9	26.9	21.6	13.5

*: Percent of recent consumption of water

DISCUSSION

The results of this research intended to provide a better understanding of the role and importance of water valuation for the agricultural sector of Mashhad in Iran.

According to results, by using the value of water per hectare and average annual water consumption in the area, value of water in m^{-3} would be 3326 Rials. And also by using them, with the discount rate, the value of water m^{-3} would be 1014 Rials. This value is fixed in a stable condition (like average of annual water consumption, discount rate, period of investment and HP model coefficient). But if each of the cases changes, the value of water would change.

By using the sensitive analysis in the value of water, the model results show that if agricultural lands are allocated to cultivation of valuable crops, discount rate of investment would increase and also if agricultural lands invested in quick return activities, period of investment decrease. And therefore, the value of irrigation water in m^{-3} increases.

CONCLUSION

This study applied hedonic pricing model, as a qualitative method for estimating value of irrigation water in Mashhad. For this purpose, at first, a HP regression was estimated by regressing most important variables on the value of land. Then, value of irrigation water was estimated via the land value approach in the same way with previous applications of HP model.

At the end of the essay, sensitive analysis of the value of water was assessed and showed that by increasing discount rate, the value of water increases. Whereas by decreasing period of investment and annual consumption of water, the value of it, decreases.

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REFERENCES

Butsic, V. and N.R. Netusil. 2007. Valuing water rights in douglas county, Oregon. Using the Hedonic Price Method, JAWRA, 43: 622-629. DOI: 10.1111/j.1752-1688.2007.00049.x

Daneshvar Kakhki, M., N. Sahnoushi., F. Salehi Reza Abadi, 2009. The determination of optimal crop pattern with aim of reduction in hazards of environmental. Am. J. Agric. Biol. Sci., 4: 305-310. www.scipub.org/fulltext/AJAB/AJAB44305-310.pdf

Ervin, D.E. and J.W. Mill, 1985. Agricultural land markets and soil erosion: Policy relevance and conceptual issues. Am. J. Agric. Econ., 67: 938-942. http://www.jstor.org/stable/1241350

Faux, J. and G.M. Perry, 1999. Estimating irrigation water value using hedonic price analysis: A case study in Malheur County, Oregon. Land Econ., 75: 440-452. http://www.jstor.org/stable/3147189

Gardner, K. and R. Barrows, 1985. The impact of soil conservation investment on land price. Am. J. Agric. Econ., 67: 943-947. http://www.jstor.org/stable/1241351

Hrovatin, N. and S.J. Bailey, 2001. Implementing the European Commission's water pricing communication: Cross-country perspectives. Utilities Policy, 10: 13-24. DOI: 10.1016/S0957-1787(02)00009-7

King, D.A. and J.A. Sinden, 1988. Influence of soil conservation on farm land values. J. Land Econ., 64: 242-255.

Lancaster, K., 1966. A new approach to consumer theory. J. Politic. Econ., 74: 132-157. DOI: 10.1086/259131

Latinopoulos, P., V. Tziakas and Z. Mallios, 2004. Valuation of irrigation water by the hedonic price method: A case study in Chalkidiki, Greece. J. Water, Air Soil Pollut., 4: 253-262. DOI: 10.1023/B:WAFO.0000044803.01747.bd

Mahan, B., S. Polasky and R. Adams, 2000. Valuing urban wetlands: A property price approach. J. Land Econ., 76: 100-113.

Miranowski, J.A. and D.B. Hammes, 1984. Implicit prices of soil characteristics for farmland of Lowa. Am. J. Agric. Econ., 66: 645-649.

Moghaddasi, R., A. Bakhshi and M. Daneshvar Kakhki, 2009. Analyzing the effects of water and agriculture policy strategies: An Iranian experience. Am. J. Agric. Biol. Sci., 4: 206-214, http://www.scipub.org/fulltext/AJAB/AJAB43206-214.pdf

North, J.H. and C.C. Griffin, 1993. Water source as a housing characteristic: Hedonic property valuation and willingness to pay for water. Water Resour. Res., 29: 1923-1929. http://www.agu.org/journals/ABS/1993/92WR02995.shtml

Torell, A., J. Libbin and M. Miller, 1990. The market value of water in the Ogallala aquifer. Land Econ., 66: 163-175.

Unnerstall, H., 2007. The principle of full cost recovery in the EU-water framework directive genesis and content. J. Environ. Law, 19: 29-42. DOI: 10.1093/jel/eql038

Vural, H. and H. Fidan, 2009. Land marketing and hedonic price model in Turkish Markets. African J. Agric. Res., 4: 71-75. http://www.academicjournals.org/AJAR

Young, R.A., 1996. Measuring economic benefits for water investment and policies. World Bank Technical Paper No. 338, the World Bank, Washington DC. http://www.citeulike.org/journal/wb-1119