Tropentag 2012, Göttingen, Germany
September 19-21, 2012

Conference on International Research on Food Security, Natural Resource Management and Rural Development organised by:
Georg-August Universität Göttingen and University of Kassel-Witzenhausen

Willingness to Pay for Irrigation Water from Groundwater in Spot Water Market by Self Selectivity: an Example from Iran

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Introduction

Understanding the economics of water can help inform decision makers of the full social costs of water use in agriculture and the full social value or benefits that agriculture's use of water can provide. However, with the wide-spread absence of well-functioning water markets, the "correct" price of irrigation water is difficult to ascertain (Hanemann, 2006). Therefore, applied economic valuation methods play a key role in water resources management. However, analysing available water markets and the willingness to pay (WTP) and price for water are particularly useful practices to define factors affecting water demand and for improving non-market valuation methods. The shortages of the available data for the water price analysis of formal and informal water markets in the context of developing countries is an issue of concern.

In Iran, the Law of Fair Distribution of Water (1983) shapes the institutions for water use. Under this law, people receive legal permission to use groundwater, which is a public good. However, these permissions are a form of property ownership and have very high shadow values, according to water charge levels of wells and water quality. There is a restriction in this law which can operate versus any water market expansion. Paragraph 28 of this law has forbidden any usages of the water which is different from the given permission. Moreover, the transmission of the permission should be done under the supervision of Ministry of Energy (MOE) with the transmission of the land to the new user by keeping the same permitted usages.

In this paper, we have focused on the factors which affect the WTP for irrigation from depleting groundwater resources of the Rafsanjan aquifer in Southeastern part of Iran during the agricultural year of 2007-2008. In spite of the Law of Fair Distribution of Water, water trade among water users has been recognised mostly among smallholders of this aquifer. The factors affecting the WTP has been analysed by the Heckman sample selection model with emphasis on the effects of the farmers' decisions to participate in the spot water market.

Material and Methods

The Heckman sample selection model was chosen for the further analysis (Heckman, 1976). The price which is paid for an extra unit of irrigation water by the farmers is considered as the WTP and dependant variable in this model. Field work was conducted for almost 3.5 months during November 2008- February 2009 in the Rafsanjan County in the south-eastern part of Iran. The main reason for selecting Rafsanjan was its unique agricultural production pattern (pistachio production) and its size. Data was gathered using two-stage random sampling. Considering the different water quality found within the study area, and the high cost of water quality studies, a readily available 4-year data set from the Rafsanjan Water Authority (RWA) was used for the first-stage sample selection. The RWA randomly sampled 60 agricultural wells within the

aquifer, and checks chemical and water parameters such as EC, pH, etc. seasonally in order to observe any quality changes that may occur. The survey comprised two different questionnaires; one concerning wells and the other concerning households. The questionnaire concerning wells was designed after consultations with irrigators, pumpers and well-representatives. This questionnaire contains questions regarding the well ownership, technical aspects, historical trends, well management, labour force, energy consumption, maintenance, water recharge and property value. The household questionnaire contains questions about garden management, garden structure, the value of harvested crops, household socioeconomic structure, inputs, garden operational costs, processing costs, water provision costs, and water trade. Also included within the questionnaires were questions asking for agricultural expenditures over a one-year period, and crop yield levels and product sale prices for a two year period.

As the sample of wells was random it includes both large and small-scale farmers. The ownership pattern is very diverse. There were cases where 2-3 wells belonged to one landlord or where one well was owned by 200 people. Representatives of the 52 pumping units[1] were interviewed, along with more than 157 farmers whose land is dispersed around the aquifer. As a result of heterogeneous water-land ownership of the area, the spot water market is not recognised by all 52 pumping units. We found that water markets were operating among those pumping units with many owners, rather than those with few owners. Spot water market was available among 41 pumping units and 145 farmers in sample. 28 farmers in this group have participated in spot water market in summer 2008. Water trade covers a small share of water use per hectare among farmers in the sample and smallholders are more active participants within water markets.

Results

There are several factors which affect the decision by farmers to buy groundwater and the willingness to pay for extra units of irrigation water. Table 1 shows the results of the Heckman regression and probit model. As participation in water markets has been discussed in Jaghdani and Brümmer (2011), the focus of this part is the WTP results obtained using the Heckman model. R statistical software has been used for the analysis.

This model can yield much more accurate results due to the availability of more observations (farmers who have participated in the water market), but the available results are consistent with the hypothesis. We find a significant $\boldsymbol{\rho}$ in the Heckman model with a negative estimate of -0.73. This shows that the average WTP of all farmers in the Rafsanjan aquifer is actually much less than those who participated in the spot water market. The significant and effective variables in the Heckman model are mainly technical. Socioeconomic characteristics of farmers do not affect the model.

The variable for pumping costs per cubic meter of water is not significant, but improves the whole model and could not be eliminated. This holds true also for the dummy variable of using other wells. The likelihood ratio test was the model selection criterion. The results show that a one percent increases of water quota per hectare reduces the WTP for extra unit of water substantially (-0.7 percent). This is not unexpected because entitlements with water use rights are generally binding for most of the farmers. Results suggest that small-scale farmers who participate in the spot water market tend to pay higher prices than the bigger farms. A one percent water level reduction increases the probability that the farmer will pay higher prices (0.4 percent) in the water market, as water is scarcer for them. As the pumping costs reduces, the farmer participating in water market pays higher prices for extra units. Therefore, if pumping costs stands high because of repairs or bad management, probably the WTP stands at lower level. Increasing in pH levels of water decreases the WTP for extra water. Although pH level can not change extremely, its change can affect the WTP dramatically. The unexpected result was the positive elasticity for the older gardens. Based on the probit function, an increase in the average

[1] Each pumping unit refers to the number of wells which irrigate a specific farm area. There could be one well or many. Usually, a pumping unit has one management pattern for all wells inside that pumping unit and it´s water is mixed for irrigation

age of the orchards leads to a decreased probability of participating in the water market. However, if the farmer participates, a one percent increase in the average age of garden will increase the WTP elasticity by 0.56 percent.

Table 1 - Heckman model

	Estimate	Std. Error	z value	Pr(>|z|)
Probit model				
(Intercept1)	10.23	4.21	2.43	0.02
Using Other Wells (dummy)	1.36	0.41	3.33	0.00
Having other jobs (dummy)	0.64	0.29	2.22	0.03
No of fragmented lands	0.18	0.06	3.34	0.00
Average age of trees in garden (year)	-0.04	0.02	-2.05	0.04
Pistachio production per ha (kg)	0.0006	0.00	2.37	0.02
Water quota per ha (cubic meter)	-0.0001	0.00	-1.96	0.05
Water level (meter)	0.02	0.01	3.50	0.00
Share of labor costs from all variable costs	-0.03	0.01	-1.92	0.05
pH	-1.42	0.53	-2.66	0.01
$EC/1000$	-0.13	0.06	-2.28	0.02
Number of observations	145			
Regression				
(Intercept2)	12.49	4.32	2.89	0.00
Using Other Wells (dummy)	0.40	0.23	1.71	0.09
log(Size of farm (ha))	-0.18	0.08	-2.35	0.02
log(Average age of trees in garden (year))	0.57	0.20	2.79	0.01
log(Water quota per ha (cubic meter))	-0.72	0.29	-2.49	0.01
log(Water level (meter))	0.43	0.20	2.13	0.03
log(Pumping cost per cubic meter (Rials))	-0.20	0.12	-1.61	0.11
$log(EC/1000)$	3.55	1.64	2.17	0.03
$(log(EC/1000))^2$	-0.76	0.50	-1.53	0.13
pH	-0.59	0.31	-1.88	0.06
σ	0.44	0.11	4.05	0.00
ρ	-0.73	0.32	-2.31	0.02
Number of observations	28			
Log-Likelihood		-61.22		
145 observations	117	censored	28	observed

Source: Study findings

As pistachio is salt-resistant, an EC up to 8000 ***μS***/cm (Iran Pistachio Association, 2011) does not significantly affect pistachio production. This likely translates also in a highly nonlinear relation between water quality and WTP. Therefore, the EC variable is added to the model in a quadratic way which was found to improve the goodness of fit. It is worth noting that these changes in the WTP caused by increased EC levels apply when we have a positive elasticity. It is possible that at lower salinity levels, salinity increases will cause increases in WTP for water. Moreover, when water is highly saline, farmers have higher WTP, as they require more water to deal with salinity. The results show that WTP elasticity is greater at lower levels of salinity than higher levels.

Discussion and Conclusion

In spite of legal restrictions, the availability of spot water market shows that market mechanism is appeared in the study area for groundwater. The empirical analysis of the decision to participate in a fragmented spot water market and of the price paid in that market showed two distinct groups with totally different WTP for extra water in the study area. The self selectivity of these two groups could be a methodological issue, neglect of which can affect the results of WTP studies in any direct or indirect approach, and is fundamental to this study. The Heckman selection model shows that the WTP of market participants is much higher than non-participants. This is reflected in the $\boldsymbol{\rho}$ term, which is highly negative and significant in the model. Additionally, the high WTP of the participants and the clear difference of that to non-participants shows that in this special case creation of functioning groundwater market can reveal the economic value of water for irrigation activities of water users and may encourage the efficient use of the resource. The fact that in the Heckman model WTP increases dramatically as water table dropping shows that the scarcity of groundwater become much more sensible issue when market mechanism are available. Using indirect valuation methods can not probably show the scarcity of *in situ* stock of groundwater in the quota setting condition with the availability of heavy subsidies for pumping energy such as Rafsanjan. It means in a market setting, more clear value is available for water to users and *in situ* value of groundwater. The finding show that the higher WTP that small farmers have for extra water can be a signal that the equity and fairness of water market price be a concerning issue. The fact that the WTP reduces for larger farmers can be a negative aspect which we have to recognise in the available limited spot water market and in the probable official formal expansion of the groundwater market. The existence of an informal water market reveals that farmers have real WTP for groundwater, and should prompt decision makers to consider legalising water markets for depleting groundwater resources such as in Rafsanjan. The high dispersion of prices paid in this market suggests legalisation of the water market may reduce price dispersion.

Further research may focus on the derived demand for water and shadow pricing of the groundwater quota using the Heckman model in the factor demand analysis when sufficient observations are available. The institutional setting of groundwater market expansion is another potential area for future research. The institutional setting of groundwater market expansion without distorting the available spot water market mechanism can be specifically analysed.

Acknowledgment

We thank the Iran Water Resources Management Company (IWRMC) for providing piezometric data. T. J J. gratefully acknowledges the help of Mr. A. N. Esfandiari; Head of Economics Desk in IWRMC and A. G. Alizadeh; Director General of Amin Padidar Pistachio Co. during the field research. Thanks to Mrs. Tayebeh Aryan, the Head of Economics Section of Mahabghodss Consulting Engineers Co. for her cooperation and help. Thanks also go to the RWA for their cooperation, especially Mr. Abbas Darvishi, the responsible person for Statistics and Information in RIWA. T. J. J. is very grateful to local people for their patience and cooperation during field surveys. The authors recognise the financial support for T. J. J from the Lichtenberg Foundation and Georg-August-Universität Göttingen during his PhD studies and this research.

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