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The Willingness to Pay by Industrial Sectors for Agricultural Water Transfer During Drought Periods in Taiwan

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Abstract

With continuous climatic change, droughts have begun to occur more frequently. In order for industrial sectors to secure a stable supply of water during the time of droughts, or to maintain the normal functions of industrial production lines, transfer of agricultural water has often been utilized. This will happen more frequently as the climates continue to change. There is a high possibility that continuous climatic change will affect the current water management operations. The IPCC (Intergovernmental Panel on Climate Change) thinks that developing the water market by targeting reasonable distribution of scarce water resources is one of the strategies for water resource management under continuous climatic change (IPCC, 2008). Past studies have often discussed the amount of compensation given in exchange for agricultural water transfer, or the costs lost resulting from water transfer. However, few studies have discussed the industrial sector's willingness to pay for agricultural water transfer from the viewpoint of managing water shortage risks. In general, if the amount of compensation is established based on farmers' WTA information, there might be situations where the amount of compensation established is inclined to become an exploitation of the surplus from transferring agricultural water. Or, the benefits of the agricultural sectors might be sacrificed or exploited. It could also be that the transaction cost would become higher for agricultural water transfers during droughts when the information of the provider and those in need are asymmetrical, which in turn would affect the benefits of the agricultural sectors and the efficiency of water resource distribution. This study uses the Contingent Valuation Method (CVM) to evaluate the amount of money industrial sectors are willing to pay under climatic change to avoid the risk of water shortage in Taiwan. We target the larger industrial areas and science parks as the objects of investigation. Interviews about the amount of willingness to pay (WTP) for transferring agricultural water are conducted in factories in the above mentioned areas, which include the Hsinchu Industrial Park, Chung-Li Industrial Park, Taichung Industrial Park, Lin-Yuan Industrial Park, Hsinchu Science Park, Central Taiwan Science Park, and Tainan Science Park. The results of this study show that the WTP for agricultural water transfer of the abovementioned industrial/science parks are $28NT/ton during drought periods.

Keywords: drought, water transfer, contingent valuation method

I. Introduction

Due to frequent droughts resulting from climate changes, water reserved for agriculture is often transferred into non-agricultural setors in order to ensure a stable water source or maintain normal production in industries. With continuing climate changes, such transferring of water has become increasingly frequent. Climate changes have a high potential of impacting current water management. The Intergovernmental Panel on Climate Change (IPCC) believes that the marketization of water to reasonably distribute scarce water resources is a management strategy for coping with climate changes. Nevertheless, the marketization of water resources or transferring water among different sectors involves the "supply" party's willingness to accept (WTA) and the "demand" party's willingness to pay (WTP). Understanding each party's respective WTA and WTP information can facilitate a fair and effective transferring and compensation mechanism.

Previous literature reviews have mainly focused on the WTA amounts for farmers to transfer out water. For example, Chiueh (2007) estimated the WTA amount for farmers in the Kaohsiung area while Chiueh and Zheng （2007) estimated the WTA amount for farmers in the Taoyuan and Shimen areas. However, very few studies have evaluated the price that non-agricultural sectors are willing to pay to transfer in agricultural water, in view of controlling water shortage risks. Generally, if prices were only established according to WTA, there is concern that such a compensation policy could easily result in the tendency to exploit the agricultural sector of their water surplus, or in other words, undermine their welfare. Moreover, if the supply and demand market information is unbalanced, it is easy for agricultural water transferring to cost more during periods of drought, thereby affecting the welfare of agricultural sectors or the efficiency of water resource distribution. The goal of this research is to design a questionnaire to survey the WTP amount set by non-agricultural sectors to transferr agricultural water in order to eliminate water shortage risks due to climate changes and to ensure a stable water supply for their sectors. Non-agricultural water users from areas that are at higher risk of water shortage due to climate changes were chosen for questionnaire sampling. The contingent valuation method (CVM) was used to evaluate the WTA prices of non-agricultural departments for transferring agricultural water to eliminate water shortage risks due to climate changes and to ensure a stable water supply for their sectors. It is hoped that information can be provided to water markets so that the cost of water allocation can be reduced, thereby facilitating a fair and efficient distribution of water resources.

2. Literature Review

The IPCC believes that the marketization of water to reasonably distribute scarce water resources is a management strategy for coping with climate changes (Huang, 2008; IPCC, 2008). In countries around the world, water resource allocation is often goes from non-agricultural sectors to agricultural sectors. Cortignani and Severini (2009) used Positive Mathematical Programming (PMP) to analyze how deficit irrigation influenced the impact of increased water supply cost, decreased water resources and increased grain prices. It was found that deficit irrigation is advantageous to efficiency and the welfare of farmers, and is helpful for setting appropriate water resource management policies. Taylor and Young (1995) asserted that as long as the benefits of transferring out irrigation water outweighs the benefits and cost of irrigation water use, then irrigation water transferring rights are economically feasible. Willies et al. (1998) used a different irrigation approach and transferring ratio to analysis the cost to temporarily transferring out water for salmon breeding to salmon farmers. Their results indicated that a contract for temporary transferring can provide water for salmon breeding. In his study of water use trends in the western United States, Frederic (2006) found that if the agricultural sectors in the western states can conserve water use by 15%, the future daily and industrial water needs of the western United States can be met. Brewer et al. (2008) collected data on the price and volume of water transferring in the western United States from 1987 to 2005, and found that both the price and frequency of agriculture-to-urban water transferring is higher than agriculture-to-agriculture water transferring. Moreover, short-term leases are gradually shifting toward permanent sales.

The marketization of water or transferring of water among sectors involves the “supply” party’s willingness to accept (WTA) and the “demand” party’s willingness to pay (WTP). Understanding each party’s respective WTA and WTP information can facilitate a fair and effective transferring and compensation mechanism. Garrida (2005) pointed out that prices can be established based on inverse water demand curves of non-agricultural sectors. Rensetti (1992) used the theory of derived demand to collect data on major Canadian manufacturers’ intake, treatment, recirculation and discharge, and calculated their demand function. Nauges and Thomas (2000) calculated the water needs for daily living in France, and analyzed the negotiation power between daily water users and water providers. The results showed that the ability of daily water users to negotiate prices and the negotiation power of providers determined the demand function. Chu et al. (2009) used the agent-based theory to analyze daily water use in Beijing, China, and established a pattern of daily water use. The authors pointed out that disclosing water use information and identifying the pattern facilitate the drafting of water management policies in Beijing, China. Danilov-Danilyan and Khranovich (2008) used the production function to analyze how establishing a market mechanism affects dependable water volume, and found that the establishment of a market mechanism provides an incentive for increasing the volume of dependable water resource.

In the past, most studies of agricultural water transferring have focused mainly on the WTA amount that was acceptable to farmers for transferring out agricultural water. For example, Chiueh（2007) evaluated the WTA amount for farmers in the Kaoshiung area while Chiueh and Zheng (2007) evaluated the WTA amount for farmers in the Taoyuan and Shihmen areas. However, few studies have evaluated the WTA amount for non-agricultural sectors based on the perspective of water shortage risk control.

Generally, if prices are only established according to WTA, there is concern that such a compensation policy could easily result in the tendency to exploit the agricultural sector of their water surplus, or in other words, undermine their welfare. Moreover, if the supply and demand market information is unbalanced, it is easy for agricultural water transferring to cost more during periods of drought, thereby affecting the welfare of agricultural sectors or the efficiency of water resource distribution.

This study designed a contingent valuation method questionnaire to evaluate the WTP amount for non-agricultural sectors when transferring in agricultural water in order to eliminate their water shortage risks caused by climate changes and to ensure a stable water supply. Non-agricultural water users from areas at higher risk of water shortage due to climate changes were chosen for questionnaire sampling. Evaluation was conducted using the contingent valuation method (CVM) and econometric analysis. It is hoped that information can be provided to water markets so that the cost of water allocation can be reduced, thereby facilitating a fair and efficient distribution of resources.

This study used the contingent valuation method to analyze the price that non-agricultural users were willing to pay for agricultural water. This method of evaluating non-market goods involved presenting hypothetical scenerios through a questionnaire. The respondents were primarily asked to valuate goods and services that do not involve transactional actions. The main feature of the contingent valuation method is ex ante judgment, that is, predictive assessment. The concepts of non-dry season, dry season and the price of transferring rights for agricultural water have yet to be implemented, and, therefore, would be very suitable for establishing a pre-assessment of pricing mechanism for transferring agricultural water.

The difference between a CVM price inquiry and general direct questionnaires is that CVM emphasizes integrating survey methods and theory. CVM became widespread in the 70's. Following the United Kingdoms Forest Law and the United States' Presidential Decree NO. 12291, using the CVM to evaluate economic benefit became even more common. In the Exxon Valdez oil spill in 1989, the amount of compensation ordered by the United States Federal Courts was based on CVM, further increasing the credibility of CVM. In 1993, due to its common use, the US government determined its natural resource policies according to CVM. The NOAA issued CVM operation guidelines, using CVM as the norm. Research has shown that in the absence of direct or indirect market price, CVM can provide a reasonable valuation of public goods or environmental goods (Smith, 1993). Mitchell and Carson (1989) and Hutchinson et al. (1995) also pointed out that if designed properly, CVM is a reliable valuation method.

3. Methods

3.1 Contingent Valuation Method Theory and Empirical Model

As described below, this study adopted the contingent valuation method to analyze the amounts that the non-agricultural industrial and science park users are willing to pay for agricultural water:

The main feature of the contingent valuation method is its ex ante evaluation, that is, predictive assessment. In this study, the market mechanism concepts for transferring agricultural water have yet to be implemented, and are therefore appropriate for pre-evaluating market mechanisms for transferring agricultural water given climate changes. As such, the WTP prices of industrial and science parks for agricultural water to ensure stable water supply and eliminate risks of water shortage due to climate changes can be further understood.

CVM can be conducted by adopting Hanemann's (1984) random utility model or Cameron's (1988) disbursement function. However, Cameron (1988) pointed out that the dichotomous selection of information in Hanemann's (1984) random utility model was not only ordered, but in the questionnaire, the base prices were also observable. Therefore, Hanemann assumed a non-sequential discrete choice model, and apparently did not adequately utilize the provided base price information. Hence, Cameron adopted a censored dichotomous choice model to directly estimate the parameters for the disbursement function and directly obtain the WTP amount. Economic theory proves that because a dual relationship exists between the indirect utility function and disbursement parameters, they are therefore representative of consumer preference. To prevent excessive bias so that all the gathered information can be fully used, this study adopted a closed dichotomous choice method questionnaire design to gather information, and also used Cameron's (1988) and Cameron and James' (1987) disbursement function to estimate the price parameters for transferring agricultural water.

In terms of manufacturer benefits, in order to use the questionnaire to determine WTP prices, a hypothetical agricultural water transferring mechanism must first be presented to the manufacturers. The questionnaire price inquiry and manufacturers' WTP or acceptable prices were then compared using Cameron's (1988) disbursement function. The estimation process is shown in Fig.1, and the empirical model is as follows:

$$Y(Q_0,Q_1,U_0,S) = E(Q_0,U_0,S) - E(Q_1,U_0,S) \quad (1)$$

Let $Y(Q_0,Q_1,U_0, S)$ *be the function for price offered by industries to transfer in agricultural water; and* $E(Q_0,U_0,S)$ *and* $E(Q_1,U_0,S)$ *be the disbursement function, where S represents market goods vectors and individual socioeconomic vectors:*

$$S = S\ (P_W, P_X, S_O) \tag{2}$$

and S_O represents its individual socioeconomic vector. If the price offered in the CVM survey is $T, then when

$$Y\ (Q_0, Q_1, U_0,\ S) \geq T \tag{3}$$

the probability that the interviewee will select this offered price can be expressed by Equation (4):

$$Pr=Pr[Y^*(Q_0,Q_1,U_0,S)-T>u] \tag{4}$$

where Y denotes the observable component and u denotes an observable random component, as expressed in Equation (5):*

$$Y\ (Q_0,Q_1,U_0,S)=Y^*\ (Q_0,Q_1,U_0,S)+u \tag{5}$$

The bid function can be estimated using the probit model (Cameron & James, 1987):

$$\begin{aligned} &Ii=1 \text{ if } Yi>Ti \\ &=0 \quad \text{otherwise} \\ &Pr(Ii=1) = Pr(Yi>Ti) = Pr(ui>TI-Xi'B) \\ &= Pr(ui/\sigma > (Ti-Xi'B)/\sigma) \\ &= 1-\phi((Ti-Xi'B)/\sigma) \end{aligned} \tag{6}$$

where Xi′B denotes explainable variables and their coefficients, and φ denotes the cumulative probability density function. The estimated bids of the interviewees can be expressed in Equation (7):

$$Yi = Xi'B+ui \tag{7}$$

However, the standard binary probit model is:

$$\begin{aligned} &Ii=1 \quad \text{if } Yi>0 \\ &=0 \quad \text{otherwise} \\ &Pr(Ii=1) = Pr(Yi>0i) = Pr(ui>-wi'\delta) \\ &= Pr(zi>-wi'\delta / v) \\ &= 1-\phi(-wi'\delta / v) \end{aligned}$$

Here,

$$Yi = wi'\delta + ui$$

Through the following transformation,

$$-(Ti,\ Xi')\begin{bmatrix} -1/\sigma \\ B/\sigma \end{bmatrix} = -wi'\delta$$

$$\delta^* = (\alpha,\gamma) =(-1/\sigma,B/\sigma)$$

the following are obtained:

$$\begin{aligned} &B = -\gamma/\alpha \\ &\sigma=-1/\alpha \\ &Yi^* = Xi'B \end{aligned} \tag{8}$$

Conforming to the probit model, Yi * represents a manufacturer's price appraisal of agricultural water, which can be reasonably calculated using this equation.

Supposing u is the logistic distribution, then based on the logistic model, the empirical results can be obtained (Cameron, 1988), as expressed in Equation (9):

$$P(Y)=[1+e-[Yi-Ti]]-1$$

As with the probit method, the following is obtained:

$$Yi^* = Xi'B \tag{9}$$

Conforming to the probit model, Yi* represents a manufacturer's price appraisal of agricultural water, which can be reasonably calculated using this equation.

In the same way, supposing u is the probit distribution, then conforming to the probit model, Yi* represents a manufacturer's price appraisal of agricultural water.

3.2 Questionnaire Design

For industrial water users, water supply stability is a critical factor in production. For example, Item 1 of the questionnaire pertained to how manufacturers resolve drought problems. Then Items 2-7 described hypothetical scenarios of varying severity of water scarcity and levels of ensuring water supply. The hypothetical scenarios assumed that the government promised agricultural water of equivalent quality, "water quality guarantee and compensation for loss due to water shortage," "exclusive pipelines for transferring agricultural water with free pipeline connection" and use of agricultural water for non-agricultural sectors during drought induced water shortage. In the hypothetical scenarios, the price lists were based on actual current domestic price for transferring agricultural water. In addition, water prices were taken into consideration in the questionnaire inquiry price. Furthermore, based on the requirements of the theoretical framework of the contingent valuation method, one or more prices ranging from extreme to moderate were set. As shown in Table 1, a total of 20 different prices were set. In other words, this study comprised 20 questionnaire configurations, from Questionnaire A to Questionnaire T. Following the hypothetical questions, Item 8 was designed to eliminate those who rejected agricultural water. The final part of the questionnaire asked for the manufacturer's basic information and water usage.

Table 1. Hypothetical scenarios and price list

Hypothetical Scenarios Questionnaire Form	*Hypothetical Scenarios (Unit: dollars/ton)*
A	2
B	3
C	4
D	5
E	6
F	7
G	8
H	9
I	10
J	11
K	12
L	13
M	14
N	15
O	16
P	18
Q	20
R	24
S	26
T	30

Source: this study.

3.3 Sampling

This study focused on industries and science parks with heavier water usage, including industries from the Hsinchu Industrial Park, Jhongli Industrial Park, Taichung Industrial Park, Linyuan Industrial Park, Hsinchu Science Park, Central Taiwan Science Park and Tainan Technology Industrial Park. The above industrial and science parks were sampled. Using the directory purchased from the Ministry of Economic Affairs, questionnaires were sent via mail to all registered manufacturers. The mailings were followed by a telephone reminder. Manufacturers unwilling to participate in the survey were excluded from the study. After verification, 1085 manufacturers participated in the survey. The questionnaires were sent out on June 21, 2010 and the response deadline was August 6, 2010. As shown in Table 2, 135 questionnaires were collected, representing a return rate of 12.44%. To facilitate understanding of the aforementioned hypothetical scenarios, the questionnaire response rate to the price list of each given scenario is shown in Table 2.

Table 2. Questionnaire response rate

Area	6/8Copies sent, A	Copies responded, B	Copies rejected, C	Invalid, D (6/21-8/6No. of calls)	Valid Sample, E=A-(C+D)	Return Rate, F=B/E
Hsinchu Industrial Park	491	29	46	276	169	17.16%
Jhongli Industrial Park	442	40	11	176	255	15.69%
Taichung Industrial Park	1,207	29	109	665	433	6.70%
Tainan Technology Industrial Park	138	10	6	79	53	18.87%
Linyuan Industrial Park	27	4	4	16	7	57.14%
Hsinchu Science Park	306	21	9	177	120	17.50%
Central Taiwan Science Park	94	2	10	36	48	4.17%
Total	2,705	135	195	1,425	1,085	12.44%

4. Empirical Results

In this study, the hypothetical scenarios assumed that the government promised agricultural water of equivalent quality (raw water), "water quality guarantee and compensation for loss due to water scarcity," "exclusive pipelines for transferring agricultural water with free pipeline connection" and use of agricultural water for non-agricultural sectors during drought induced water shortages. Table 3 shows the result of multinomial logit model analysis. The relationship between price list and WTP conformed to demand theory. The significance variables were WT2T (the maximum amount of water that can be transferred), and X78 (the amount of water taken in 2009 influenced the willingness of industries to assume the price of transferring agricultural water during drought season.) In the conditions set under the hypothetical scenarios, the acceptable price that non-agricultural sectors were willing to pay for transferring agricultural water was NT$28 per ton. The predictive value was 66% and above.

Table 3. Results of Multinomial Logit Model Analysis

Variable	English Code	Coeff.	Std.Err.	t-ratio	P-value
constant	ONE	-0.04736	0.876312	-0.05405	0.956898
price list	BIT2	-0.03027	0.030223	-1.00143	0.316618
acceptable amount of water for transferring	WT2T	0.032882	0.012232	2.68823	0.007183
amount of water taken in 2009	X78	-1.39E-05	4.92E-06	-2.83035	0.00465
type of company	FAC	0.845882	0.664886	1.27222	0.203294
location of factory	LOCATE	-7.33E-02	1.03E-01	-0.71373	0.475394
interrupted production due to water shortage	SOL1B	0.100238	0.098517	1.01746	0.308933
number of days of factory reserve water	SOL1C2	-0.05525	0.061541	-0.89772	0.369334

5. Conclusion and Suggestions

During droughts brought about by climate changes, non-agricultural sectors often transfer in agricultural water in order to ensure a stable water supply or maintain normal operations of production lines. With continuing climate changes, such water transferring has become increasingly frequent. Climate changes are very likely to impact current water management. Collecting a complete set of data is the foremost condition for designing an appropriate water transferring mechanism. This study focused on industries and science parks with heavier water usage, including industries in the Hsinchu Industrial Park, Jhongli Industrial Park, Taichung Industrial Park, Linyuan Industrial Park, Hsinchu Science Park, Central Taiwan Science Park and Tainan Technology Industrial Park.

Results showed that among the sampled industries, the WTP price for non-agricultural sectors to transfer agricultural water during droughts was NT$28 per ton. The survey showed that industrial water users were already aware of payments in exchange for using agricultural water. The Intergovernmental Panel on Climate Change (IPCC) has suggested that in times of climate changes, an appropriate water exchange mechanism should be established for equitable and reasonable allocation of scarce water resources, and for protecting the rights of agricultural sectors.

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