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Measuring the value of water quality improvements in Lake Tai, China*

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Abstract: Despite widespread concerns and elevated policy debates, little is known about the Chinese public's perceptions of water pollution and willingness to cooperate with government policies. Based on survey data, this study examined Lake Tai resident perception of water pollution, willingness to pay (WTP) for water quality improvements, and its influencing factors. Contingent valuation (CV) results showed that respondents would prefer to pay 141 CNY per household a year, approximately 0.70% of their annual per capita disposable income, as an environmental fee to improve water quality in Lake Tai. Aggregate WTP for all five lakeside cities of Lake Tai was estimated at about 3.8 billion CNY, without discounts, in the next ten years. WTP was found to increase with income and female respondents were willing to pay more than males. Those respondents who were dissatisfied with water quality were more likely to pay more. The usage of Lake Tai did not strongly affect WTP.

Key words: Water quality, Willingness to pay (WTP), Contingent valuation (CV), Lake Tai
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1 Introduction

In May of 2007, the blue-green algae bloom on Lake Tai prompted the suspension of running water in and around the major city of Wuxi, China for 6 d, forcing as many as 2 million people to rely on bottled water (http://www.worldwatch.org/node/5176). Blue-green algae (cyanobacteria), which occur naturally in surface waters, are microscopic bacteria that are photosynthetic. Microcystis aeruginosa is the dominant species of the bloom-forming cyanobacteria, which are frequently found in the eutrophic Lake Tai (Ren *et al.*, 2010). The overgrowth of algae is being stimulated by nitrogen and phosphorus from industrial and agricultural pollution, domestic wastewater discharge, and fish farming along the lake (Chen *et al.*, 2003). When conditions are favorable, including light and temperature, levels of nutrients, and lack of water turbulence, blue-green algae can quickly multiply into a bloom.

The water pollution problem has existed for some time in Lake Tai. Monitoring data on water quantity and quality of Lake Tai from 1998 to 2006 show that the average annual values for total phosphorus (TP) and total nitrogen (TN), two key pollutants discharged into the lake, are 1600 and 39300 t, respectively (NDRC, 2008). China uses a five-grade classification scheme for surface water quality, the higher the grade, the worse the water quality. Environmental Quality Standards for Surface Water (GB3838-2002) defines five water quality grades for different environmental functions: Grade I for headwaters and natural reserve; Grade II for the 1st class of drinking water sources and habitats of rare aquatic organisms; Grade III for the 2nd class of drinking water source, aquiculture, and human contact; Grade IV for water source of industrial use and recreation area for indirect human contact; Grade V for water sources of agriculture use and landscaping requirements. Water quality worse than Grade III cannot be used as drinking water. The average water quality in Lake Tai basin declined from Grade III to Grade IV during the 1980s through 1990s. Since 2000, Lake Tai

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has been seriously polluted and average water quality has been worse than Grade V (Huang *et al.*, 2006).

Although efforts to manage water pollution have not stopped (Li and Yang, 1995; Rose *et al.*, 2004; Chang *et al.*, 2006; Zhu G.W. *et al.*, 2007; Li *et al.*, 2008; Zhu J.G. *et al.*, 2010), pollution has outstripped treatment. One of the reasons is the lack of funds at the disposal of local government for investment in the wastewater sector (NDRC, 2008). Planned investments for water pollution management in the 9th Five-Year Plan and the 10th Five-Year Plan were 12.95 and 22.01 billion CNY, respectively, but actual investments were 10 and 16.87 billion CNY, respectively (NDRC, 2008). Under these two Five-Year Plans, priorities were assigned to: (1) improve wastewater management, particularly collection and treatment of domestic sewage; (2) improve water quality by reducing total phosphorus (TP) discharges into heavily polluted water bodies and by transferring higher quality water from the Yangtze River to increase circulation and improve water quality in the lake and canal system; and (3) strengthen the local capacity for water environment monitoring and management. However, many important pollution sources, such as non-point source pollution from agriculture, animal husbandry facilities, and the vast numbers of small-scale industries, have yet to be effectively addressed by the national or local environmental regulatory authorities (World Bank, 2004).

More attention has been devoted to Lake Tai pollution with the blue-green algae incident in Wuxi. Premier Jia-bao WEN ordered a formal probe into the massive algae growth just after the crisis (Bordeen, 2007). National Development and Reform Commission (NDRC), in coordination with other ministries and commissions, proposed the Overall Scheme for Comprehensive Cleaning Water in Lake Tai Basin in April, 2008, with a total investment of 111.50 billion CNY. The short-term goal of the scheme is that the average water quality would be improved from worse than Grade V in 2005 to Grade V in 2012 and the eutrophication trend would be curbed. The long-term goal is that average water quality reaches Grade IV in 2020 from Grade V in 2012 and the eutrophication level would be alleviated to light or medium eutrophication.

Despite widespread concerns and policy suggestions and debates, little is known about public perceptions of water pollution and willingness to cooperate with government policies, a component that is critical to the success of national and local policy efforts. There have been numerous studies reporting the public estimated value of water quality improvements or water resource protection in developed countries (Desvousges *et al.*, 1983; Edwards, 1988; Shultz and Lindsay, 1990; Carson and Mitchell, 1993; Spencer *et al.*, 1998; Machado and Mourato, 2002; Hökby and Söderqvist, 2003; Jones *et al.*, 2008). Recently, researchers in developing countries have begun to pay attention to this subject, although improved environmental quality is believed to be a luxury for the world's poor (Akter, 2008; Devi *et al.*, 2009; Vásquez *et al.*, 2009; Gupta and Mythili, 2010).

In evaluating the benefit of environmental improvements, the contingent valuation method (CVM) has been used as an important tool in the past five decades (Davis, 1963; Mitchell and Carson, 1981; 1989; Smith, 2006). The CVM is a survey or questionnaire-based approach to the valuation of non-market goods and services. Typically the survey asks how much money people would be willing to pay or accept to maintain the existence of or be compensated for the loss of an environmental feature (Hanemann, 1999; Boyle, 2003). Despite some known potential biases, such as hypothetical bias, starting point bias, and non-response bias (Cummings *et al.*, 1995; Herriges and Shogren, 1996; Bjornstad *et al.*, 1997), the CVM offers certain advantages, e.g., the ability to capture "non-use" values.

A paucity of literature on the value of water quality improvement exists in China. Using the CVM, the objectives of this paper were to: (1) examine lakeside resident perception of water pollution; (2) measure resident willingness to pay (WTP) or value for water quality improvements; and (3) identify the factors that influence the WTP.

2 Methods

2.1 Study design

Lake Tai is the third largest freshwater lake in China, with an estimated area of 2338 km^2 and an average depth of 2 m. It is located on the border of

Jiangsu and Zhejiang provinces. The location of Lake Tai is also the center of the Yangtze River Delta, which is surrounded by urbanization and economic growth. The lake serves more than 33 million people in the Yangtze River Delta, serving drinking water, flood control, shipping, waste disposal, fisheries, aquaculture, and farming. There are five prefectural-level lakeside cities around the Lake Tai: Suzhou, Wuxi, Changzhou, Jiaxing, and Huzhou (Fig. 1). The first three cities are under the jurisdiction of Jiangsu Province and the latter two belong to Zhejiang Province.

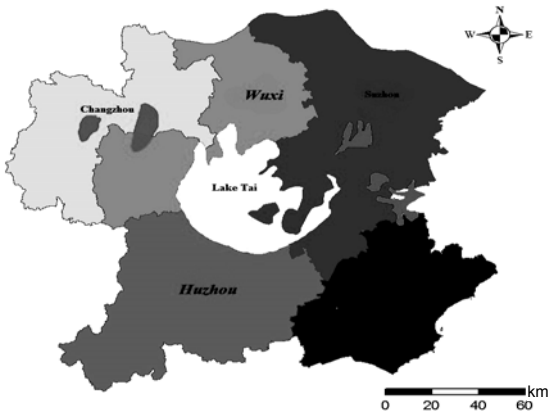

Fig. 1 Location of the survey cities in Lake Tai Basin

The survey was designed to test a simple hypothesis: residents with poor water quality are willing to pay more for water quality improvements than those with good water quality. In terms of water quality, the western part of Lake Tai is better than the eastern, and the southern is better than the northern. As the venue of the 2007 blue-green algae incident, Wuxi City was the most appropriate survey site. Wuxi City is located in the north bank and is a low-lying region of Lake Tai Basin (Fig. 1). Huzhou City, lying in the south bank and a high-lying region, was chosen for comparison. Residents of Wuxi City were hypothesized to be willing to pay more for water quality improvements because they suffered from tainted tap water, panic buying of bottled water, and unpleasant odors during the blue-green algae incident; in contrast, residents of Huzhou City, a region less affected by cyanobacteria, were hypothesized to have lower WTP.

Fig. 2 compares water quality in Wuxi and Huzhou based on data collected in 2007. Clearly, Wuxi's water quality was worse than Huzhou's. Indeed, 69.1% of the monitored section or points (the monitored section or points are set up and distributed in the lake area for sampling inspecting the water quality) are at the lowest grade, worse than Grade V.

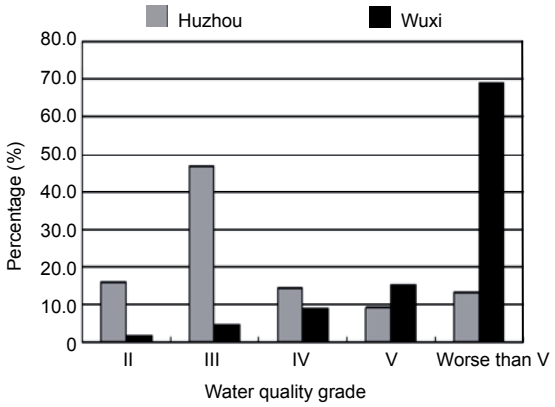

Fig. 2 Water quality grade at survey cities in 2007

Sources: 2007 Wuxi Water Resource Communique and 2007 Huzhou Water Resource Communique. The water quality parameters measured include dissolved oxygen (DO, mg/L), ammonia nitrogen (mg/L), biochemical oxygen demand (BOD, mg/L), and total phosphorus (TP, mg/L), etc

In addition to water quality differences, there are other discrepancies between the two cities as well (the data of this paragraph were collected from 2008 Jiangsu Statistical Yearbook and 2008 Zhejiang Statistical Yearbook). For instance, the Wuxi metropolis had a population of 2.36 million in 2007, twice as large as Huzhou metropolis' population (1.08 million). The per capita gross domestic product (GDP) of Wuxi City was 12 680 USD, almost one and a half times higher than Huzhou's (5281 USD). However, their per capita disposable incomes were quite close, 2890 USD for Wuxi and 2770 USD for Huzhou.

Working with the local Housing Authority, five residential communities in two cities with different housing prices (from lower to higher) were selected as survey sites to ensure a representative sample. Then all property management agencies in those communities were contacted by the Housing Authority to coordinate the survey. Local college students were hired to carry out the in-person interviews. All the students were given the necessary training before conducting the survey. During the first half-day

training session, the students were given background information, and basic knowledge of water quality and water pollution. In the second part of the training, students were asked to go back to do a couple of practice surveys. The purpose of the second training in the following day was to obtain potential interviewers' feedback and to respond to their questions so that the formal survey could be carried out smoothly.

2.2 Modeling and data collection

CV questions can be open or closed-ended. The former does not constrain respondent answers because no response category is given, whereas the later constrains answers by specifying response categories. Since closed-ended questions are much easier for respondents to answer, most of the CV questions are closed-ended. Closed-ended questions included dichotomous choice and payment card questions. The dichotomous choice question has been the dominant form of CV question since Bishop and Heberlien (1979). Two-bounded dichotomous choice was used in our survey, which raises an additional aspect. For example, if the respondents say "yes" with the first bid amount T, then an iterative-bidding question with higher amount Tu will follow; if they say "no" with the first one, then a lower bid amount Td will be followed. Therefore, $Td<T<Tu$. In the case that respondents may not ascertain their answers to the questions, there is an additional answer. When conducting statistical analysis, it will be merged with the choice of "no" instead of dropping them from the sample. The random utility model of Hanemann *et al.* (1991) is adopted in this research. The results with two-bounded dichotomous choice include four categories: "yes/yes", "yes/no", "no/yes", and "no/no". The probability, when the first bid amount T_i has the answer "yes" and the higher amount Tu_i also has "yes", is defined as P^{yy}; the probability, when the first bid amount T_i has the answer "yes" and the higher amount Tu_i has "no", is defined as P^{yn}; the probability, when the first bid amount T_i has the answer "no" and the lower amount Td_i has "yes", is defined as P^{ny}; the probability that both two questions are "no" is defined as P^{nn}. We supposed that $G(T, \beta X)$ is a cumulative distribution function, in which X represents the individual attribute variable and the cognitive variable of environment, and β is the parameter. Then we have

$$P^{yy}(T_i, Tu_i) = \mathrm{pr}(T_i < Tu_i < \max(\mathrm{WTP}_i)) = 1 - G(Tu_i, \beta X_i), \tag{1}$$

$$P^{yn}(T_i, Tu_i) = \mathrm{pr}(T_i < \max(\mathrm{WTP}_i) < Tu_i) = G(Tu_i, \beta X_i) - G(T_i, \beta X_i), \tag{2}$$

$$P^{ny}(T_i, Td_i) = \mathrm{pr}(Td_i < \max(\mathrm{WTP}_i) < T_i) = G(T_i, \beta X_i) - G(Td_i, \beta X_i), \tag{3}$$

$$P^{nn}(T_i, Td_i) = \mathrm{pr}(\max(\mathrm{WTP}_i) < Td_i < T_i) = G(Td_i, \beta X_i), \tag{4}$$

where pr means the probability.

Then dummy variables about the answers of respondents are defined as If_i and Is_i. When obtaining "yes" or "no" with the first bid amount (T), If_i=1 or If_i=0; when obtaining "yes" or "no" with the second bid amount, Is_i=1 or Is_i=0. Therefore, the log-likelihood function of two-bounded dichotomous choice is

$$\begin{aligned}\ln L = &\sum \{If_i Is_i \ln P^{yy}(T_i, Tu_i) \\ &+ If_i(1 - Is_i) \ln P^{yn}(T_i, Tu_i) \\ &+ (1 - If)_i Is_i \ln P^{ny}(T_i, Td_i) \\ &+ (1 - If)_i (1 - Is_i) \ln P^{nn}(T_i, Td_i)\} \\ = &\sum \{If_i Is_i \ln[1 - G(Tu_i, \beta X_i)] \\ &+ If_i(1 - Is_i) \ln[G(Tu_i, \beta X_i) - G(T_i, \beta X_i)] \\ &+ (1 - If_i) Is_i \ln[G(T_i, \beta X_i) - G(Td_i, \beta X_i)] \\ &+ (1 - If_i)(1 - Is_i) \ln[G(Td_i, \beta X_i)]\}.\end{aligned} \tag{5}$$

Suppose that $G(T, \beta X)$ fits the log-logistic distribution and then parameters can be inferred by the maximum likelihood method. If P is the probability that respondents answer with "yes", and α_0, α_1, and β are parameters, the logit model could be inferred as

$$P = [1 + \exp(-\alpha_0 - \alpha_1 \ln T_i - \beta X_i)]^{-1}. \tag{6}$$

By Eq. (6), calculate the integral of T and the result with the average of T is mean WTP. When P=0.5, the result of T is median WTP, standing for that there are half of respondents who can accept.

Fig. 3 provides the text of the contingent participation scenarios corresponding with the current policy situation. As mentioned above, the two-bounded dichotomous choice was used to elicit WTP.

The bid amounts include 20, 50, 80, 100, 150, 200, 300, 400, and 500 CNY, which were based on information about the underlying WTP distribution obtained from pilot studies. The initial bid amounts are 50*, 100*, 150*, 200*, and 300* respectively for each 100 questionnaires. The second bid amounts are adjusted correspondingly. In consideration of the acceptability of the residents, the payment is designed as a house-based annual amount other than lump-sum amount. In accord with the targets proposed by the Overall Scheme for Comprehensive Cleaning Water in Lake Tai Basin (Fig. 3), the term of payment is set for ten years from 2010 through 2019.

In order to achieve the targets (i.e., water quality of Lake Tai basically reaches Grade IV standard, and a part of it could reach Grade III standard) in Overall Scheme for Comprehensive Cleaning Water in Lake Tai Basin, we propose to establish a Lake Tai Fund to clear up water and strengthen protection of Lake Tai.

Would your family be willing to pay **100*** CNY as an environment fee every year for the period 2010–2019?

A) accept B) not accept C) do not know

If you "accept" above, the environment fee rises to **200** CNY per year, would your family be willing to pay?

A) accept B) not accept C) do not know

If you "do not accept" above, the environment fee falls at **50** CNY per year, would your family be willing to pay?

A) accept B) not accept C) do not know

Fig. 3 Contingent valuation scenarios
100 CNY equal to 14.80 USD in 2008

Since the success of CV studies depends critically on how well respondents understand what exactly they are asked to value, some information was given before WTP questions were asked in the form of boxed text with bold type in the questionnaire, including: (1) the classification of surface water quality from Grade I to Grade V (Fig. 4); (2) the consequence of water pollution showed both by simple text and color photographs; (3) a brief introduction about the Overall Scheme for Comprehensive Cleaning Water in Lake Tai Basin.

A pilot survey was conducted to test the survey instrument. The surveys were finally implemented in two weekends in October, 2008, about one and a half years after the blue-green algae incident. The student-interviewers were permitted to enter resident communities and put a desk near the main entrance. Most respondents were caught randomly during the period when they were taking exercise in the community garden or on the way to shopping, etc. A few random interviews were conducted indoors. To maintain respondent interest, a small gift was given after they finished the questionnaire. Each community was allocated 100 questionnaires for a total of 500 questionnaires in each city. A total of 440 valid questionnaires were obtained from Huzhou City and 434 from Wuxi City; hence, the effective response rate was 88.0% and 86.8%, respectively.

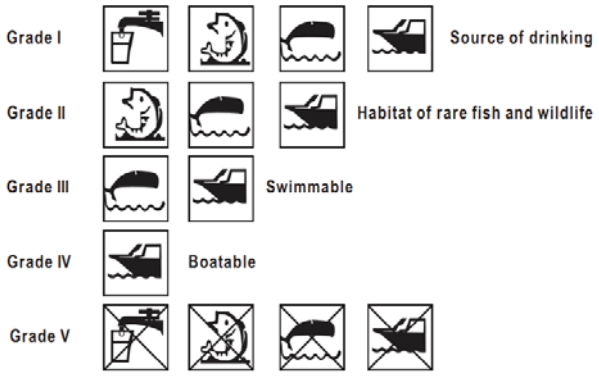

Fig. 4 Classification of surface water quality

3 Results and discussion

3.1 Factors influencing resident valuation

Potential factors influencing resident valuation are listed in Table 1. First of all, Lake Tai has a use value to the lakeside residents, such as a drinking water source, for swimming, fishing, and boating, etc., and different utilizations of Lake Tai may influence resident valuation of the lake and visitation frequency. Since Huzhou City obtains its drinking water from the Cisborder Rivers, while the drinking water source of Wuxi City is mainly Lake Tai, we asked questions such as "how often do you visit Lake Tai as a leisure venue (i.e., walking and picnicking by the lake; boating, playing and fishing at the Lake)?" According to the survey, the visiting frequency of Wuxi residents is more than those of Huzhou's, which probably is due to the fact that several famous scenic spots of Lake Tai are inside or very close to the metropolitan area of Wuxi City. Thus, we assume that Wuxi residents are more likely to put more value to water quality improvements.

According to the survey, the percentage of people who are not satisfied with the current water quality of Lake Tai is about 58.6%, which is lower than what we expected. About 8.9% and 3.0% of the

Table 1 Potential factors influencing resident valuation (%)

Potential factor	Percentage of resident	
	Huzhou	Wuxi
Visit frequency to Lake Tai		
Nearly every day	3.4	2.1
2–3 times a week	2.5	6.2
2–3 times a month	11.1	38.9
2–3 times a year	65.9	46.8
Never	16.8	6.0
No answer	0.2	–
Satisfaction degree with water quality of Lake Tai		
Very satisfied	0.5	1.8
Satisfied	30.7	31.6
Not satisfied	58.6	63.4
Do not know	8.9	3.0
No answer	1.4	0.2
Concerned indicators of water quality		
Odor	39.3	62.0
Turbidity	48.2	48.6
Color of water	42.7	47.0
Floating debris (such as rubbish and oil)	56.1	44.9
Safety of drinking	46.8	48.4
Effects on living beings	24.8	15.0
Others	0.7	1.2
No answer	0.5	0.7
Information needed		
Causes of water pollution in Lake Tai Basin	49.1	56.7
Effects of water environment deterioration on human being and their lives	70.5	75.6
The most valid activities to protect Lake Tai	44.5	49.5
Regulations and the ongoing projects to protect Lake Tai established by country and local government	52.0	54.4
Time and expenses spent on the pollution treatment of Lake Tai	24.5	32.9
Others	2.7	1.6
No answer	0.5	1.2
Participation in public benefit activity		
Often participate	1.1	1.2
Have participated	10.7	18.0
Desire but no opportunities	68.4	53.9
Never want to participate	19.8	26.5
Environmental protections in daily life		
Less use or not use scour with phosphorus	67.3	68.9
Minimize the use of scour when cleaning tableware	65.2	50.9
Set mesh objectives in kitchen to prevent the rubbish into sewer	64.5	67.7
Wash clothes with appropriate amount of lotion	52.0	47.2
Keep water saving in daily life	74.5	74.0
Others	0.7	0.5
No answer	0.7	2.1

respondents in Huzhou City and Jiaxing City, respectively, responded: "do not know".

Following the above questions, respondents were asked a series of questions. Table 1 summarizes their responses to those questions. The most concerned indicator, in Huzhou City, is floating debris (such as rubbish, oil, and so on), followed by turbidity, safety of drinking, and color of water, with respective percentages of 56.1%, 48.2%, 46.8%, and 42.7%. For Wuxi City, the corresponding percentages for odor, turbidity, safety of drinking, color of water, and floating debris are 62.0%, 48.6%, 48.4%, 47.0%, and 44.9%. Thus, both in Wuxi and Huzhou City, the safety of drinking water is not the most important aspect of concern to residents. Even in Wuxi, where the drinking water is from Lake Tai, its residents pay much more attention to the odor of water than the safety.

We found that 49.1% and 56.7% of the respondents in Huzhou and Wuxi, respectively, want knowledge about "causes of water pollution in Tai Lake Besin". The percentage of the respondents who want to know "the effects of water deterioration on human being and their lives" are 70.5% and 75.6% in Huzhou and Wuxi, respectively. Since Wuxi residents witnessed the blue-green algae incident in 2007, they demanded more information than Huzhou residents on the causes and consequences of water pollution. Likewise, desires for information about "the most valid activities to protect Tai Lake" and "regulations and the ongoing projects to protect Lake Tai established by country and local government" are ranked high in Wuxi as well. Overall the residents in two sampling cities are short of knowledge about Lake Tai's water pollution and its impact. This may explain their valuation of water quality improvements.

The residents' environmental consciousness and behavior in daily life will impact their valuation of water quality improvements as well. According to this survey, 19.2% of the respondents in Wuxi City "often participate in environmental protection activities" or "have participated". However, the ratio in Huzhou City is 11.8%, which is a little bit lower. In fact, 68.4% of the respondents in Huzhou City and 53.9% in Wuxi City confess that they "want to take part in the activities, but do not have the opportunity to do so". This suggests that, while participation in publicly beneficial activity involving environmental protec-

tion is not high, the desire is very strong. Therefore, government or other societies should strengthen the organization of public activities and create more opportunities for urban residents.

Over half of respondents in Huzhou City answered that they would "less use or not use scour with phosphorus", "minimize the use of scour when cleaning tableware", "set mesh objectives in kitchen to prevent the rubbish into sewer", "wash clothes with appropriate amount of lotion" and "keep water saving in daily life". In contrast, except for "wash clothes with appropriate amount of lotion" is lower than 50% in Wuxi City, other items were above 50% in endorsement. As shown in Table 1, the residents recognize the problem of pollution and use environmental protection behaviors in daily life.

3.2 Estimates of the value of water quality improvements

The main purpose of this study is to estimate the urban resident WTP for water quality improvements in Lake Tai. Analyzing the survey data from Huzhou and Wuxi cities with Eviews3.1, the variables and their means are summarized in Table 2.

The results suggest that the coefficient on ln(T) is significantly negative; that is, the higher the bid amount, the more impossible for respondents accept the amount. The fact that the coefficient of Huzhou is slightly greater than that of Wuxi indicates that the respondents of Huzhou are more sensitive to the bid. The income elasticity of Huzhou is greater than that of Wuxi, as well, because the gaps among the coefficients of different income groups in Huzhou are significantly greater than the gaps among the Wuxi's; although, the coefficient of INC1 (2000–3999 CNY) in Huzhou did not pass the significance test.

The variable GEN gender is not statistically significant; however, it is interesting that the sign of the coefficient is negative. Since GEN is coded 1/0 (1=male, 0=female), the interpretation can be that for male respondents the bid amounts accepted would be lower than for females respondents. That females have higher WTP for environmental products or services has already been reported (Torgler *et al.*, 2008; Liebe *et al.*, 2011). The situation of WAT is similar to GEN. The more dissatisfied with water quality, the less likely the respondent was to support the water quality improvements plan. As for the variable of USE, we assumed that the more frequent use of Lake Tai, the more willing to pay and improve the environment of Lake Tai. However, the results have not proved the hypothesis. Surprisingly, the USE3 for

Table 2 Description of variables used in the model

Variable	Description	Mean	
		Huzhou	Wuxi
Dependent			
T	Initial bid amount	158.937	161.453
Tu	Higher second bid amount (2nd up)	297.101	301.970
Td	Lower second bid amount (2nd down)	79.444	80.813
I	Initial bid amount: accept=1, do not accept=0	0.599	0.589
Iu	2nd up: accept=1, do not accept=0	0.275	0.227
Id	2nd down: accept=1, do not accept=0	0.109	0.126
Independent			
GEN	Male=1, female=0	0.466	0.433
INC1	Income per month, 2000–3999 CNY=1, other=0	0.379	0.399
INC2	Income per month, 4000–5999 CNY=1, other=0	0.319	0.298
INC3	Income per month above 6000 CNY=1, other=0; focus group: income per month lower than 2000 CNY	0.200	0.212
WAT	Not satisfied with water quality of Lake Tai=1, other=0	0.586	0.634
USE1	Go to Lake Tai as leisure every day=1, other=0	0.034	0.021
USE2	Go to Lake Tai as leisure for twice or three times one week=1, other=0	0.025	0.062
USE3	Go to Lake Tai as leisure for twice or three times one month=1, other=0; focus group: go to Lake Tai twice or three times per year or never go to Lake Tai as leisure	0.111	0.389

Wuxi City has a negative symbol. One possible explanation for this result is that the focus group seldom or never goes to Lake Tai because they mind the situation of water quality degradation, thus giving greater attention to water quality improvements than the group who goes to Lake Tai as leisure for twice or three times one month. However, for those people who often use the lake, the higher the WTP.

The results of the bid estimation are also summarized in Table 3. The median WTPs in Huzhou City and Wuxi City are quite close. In contrast, the mean WTPs in two cities have obvious differences. Since the median WTP is less sensitive to outliers than mean WTP, the median WTP is adopted. But according to this measure, Wuxi residents did not provide more value to water quality improvements than Huzhou residents as hypothesized because the bid amount in both research cities is nearly the same, 141 CNY (the equivalent of 21.83 USD according to the 2008 exchange rate value) per household every year, about 0.70% and 0.67% of their annual per capita disposable income. These expenditures on water are much lower than typical water charges in Organization for Economic Cooperation and Development (OECD) countries, the affordability threshold of 3% of disposable income suggested by international organizations (OECD, 2003). Although it seems from the indicators of GDP, either gross value or per capita value, that Wuxi City is much wealthier than Huzhou City, the per capita disposable income of urban residents has no significant difference, as described above, proving once again that income is the most significant factor influencing the bid (Gupta and Mythili, 2010). As to the actual WTP amounts, it seems there is no comparability. In a meta-analysis of CV studies, KC and Collins (2011) gathered a total of 109 observations from 49 CV studies of surface water quality in the Appalachian Region from 1981 to 2009; the data show that estimated annual mean WTPs (2009 USD) per household varied from 4.38 to 402.40 USD.

Table 3 Multivariate models and the inferred results of WTP

Variable	Huzhou		Wuxi	
	Coefficient	*T*	Coefficient	*T*
C	4.922***	5.066	4.551***	4.751
ln(*T*)	−1.032***	−5.568	−0.974***	−5.285
GEN	−0.031	−0.144	−0.049	−0.234
INC1	0.327	0.878	0.832**	2.198
INC2	0.945**	2.448	0.939**	2.361
INC3	1.287***	3.026	0.915**	2.183
WAT	−0.195	−0.867	−0.191	−0.858
USE1	0.061	0.101	0.751	0.901
USE2	1.335*	1.642	0.676	1.403
USE3	0.019	0.056	−0.238	−1.066
Log-likelihood	−254.973		−262.531	
Median WTP (CNY)	141		141	
Mean WTP (CNY)	474		330	

* Variables are significant at the 10% level; ** variables are significant at the 5% level; ***variables are significant at the 1% level. *C* is a constant

4 Conclusions

This study analyzed factors influencing WTP for water quality improvement in the Chinese cities of Huzhou and Wuxi based on survey data. A random utility model was estimated by the maximum likelihood method. Results showed that respondents would be willing to pay about 141 CNY per household every year (approximately 0.70% of their annual per capita disposable income) as an environmental fee to improve water quality in Lake Tai. Potentially, the government could collect 3.8 billion CNY in environmental fees (undiscounted) in the five lakeside cities of Suzhou, Wuxi, Changzhou, Jiaxing, and Huzhou (with total urban households of 2.68 million in 2007) during the next ten years. Though potential biases may exist, the results are helpful for policymakers, suggesting that raising funds from public is a possible way to solve the problem of environmental protection investment shortages. With China's rapid economic growth, environmental goods are no longer a luxury in developed areas such as Lake Tai basin. More and more people are willing to pay for a better environment.

WTP was found to increase with income, and female respondents were found to be willing to pay more than male. Respondents who were not satisfied with water quality were more likely to pay for improvements in water quality than those who were satisfied with water quality. The usage of Lake Tai does not strongly affect WTP. As a whole, respondents were not satisfied with the water and paid much

attention to all sorts of indicators of water quality. They also recognized the importance of living with pollution and most of them had taken environmental protection behaviors in daily life. However, public activities for water quality improvement are not active. Lack of opportunities is one of the reasons, suggesting that more public activities are needed, and government and other non-government organizations could play a more important role. Residents desire more information about the environmental changes of Lake Tai because information transparency was insufficient, and propaganda about protection of Lake Tai was ignored by mass media (such as TV, newspapers, and so on).

The results indicate that local residents are willing to pay to improve water quality of Lake Tai, suggesting that net welfare could increase if the government is able to collect and use the potential fees to improve water quality. Economic efficiency in improving water quality can be achieved by capturing the lake household benefits in the form of fees. Establishing appropriate channels and collecting the fees is another challenge that needs further investigation. The value of improved water quality to local residential lake water users and the indirect benefits for other sectors were not included in this study. A more comprehensive valuation approach is needed in the future to understanding the value of improved water quality for other stakeholders.

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