Residents' Willingness to Pay for Improving Drinking Water Quality: A Case Study of Chang-Zhu-Tan City Cluster of Xiangjiang Valley in Hunan Province, China

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Abstract. The water quality plays an important role for residents living in Xiangjiang valley, Hunan province, southern China. In this study, the contingent valuation method (CVM) was used to estimate the value for improving water quality of Xiangjiang for residents who live in in Chang-Zhu-Tan city cluster including Changsha, Zhuzhou and Xiangtan of Xiangjiang valley. Based on pre-interviewed, 220 questionnaires per city were carried out in Chang-Zhu-Tan city cluster between March and August 2010. Among 660 questionnaires, the 623 questionnaires accounting for 94.3% were effectively. About 99.3% respondents thought that Xiangjiang was becoming worse and it was necessary to improve water quality for their health, while 0.7% took it easy. About 70.1% residents wanted to support government to take active measures to improve water quality, while, 29.9% refuse to pay due to sex, age, income, education, and occupation of residents in the interview. According to ranges of willingness to pay (WTP) for residents from CNY 2.0 to 50.0 Yuan (from US$ 0.3 to 7.46), the average WTP was calculated CNY 17.18 Yuan (US$ 2.56) per month per household, and the total economic value was CNY 0.848 billion Yuan (US$ 0.127 billion) for Chang-Zhu-Tan city cluster. Residents were willing to contribute a portion of their incomes to improve the quality of drinking water. Among all factors, there were significant relationships between income and sex and WTP (p<0.05), while the relationships between WTP and the education, age, and occupation of resident's are no-significant.

1. Introduction
Water is an important natural and valuable source for sustainable development of economy and society, especially for water scarcity of China (Jiang 2009). According to the report, there 83 billion m³ of water will be essential for China maintaining its current pattern of economic growth (The World Bank, 2006). However, due to the rapid development of economy, industrialization, and urbanization and so on for the past 30 years, the water pollution happened in rivers, lakes and reservoirs (Yang et al., 2012a; 2012b; 2013; Wang and Yu, 2014). The China Water Resources Bulletin for 2010 demonstrated that the qualification rate for water quality of surface water was only about 60%, and for groundwater was only 38% (Ministry of Water Resources of the People's Republic of China, 2010).
Among all tributaries, Xiangjiang called the mother river as a major source of drinking, shipping, irrigation, industrial, and recreational water in Hunan province southern of China, is one of the largest tributaries of the Yangtze River. In this basin, due to the highly developed mining and metallurgical industries like Zhuzhou metallurgical corporation, Xiangtan steel group, and Shuikoushan mining bureau, the elevated pollutants like Hg, Cd, Pb, Zn, Cu, and Cr have discharged and accumulated in its sediments, especially in the middle and lower reaches of Xiangjiang (Li, 2006; Zhang et al., 1989, 2009, 2010; Mao et al., 2013; 2014). The monitored data showed that 56% and 50% monitors among 40 water monitor stations exceeded the standard level in 2006 and 2007, respectively (Wang, 2008), and implied a higher risk to local residents drinking untreated water during low-flow periods (Zhang et al., 2014). It is estimated that the pollution damages is up to CNY 40 billion (US$ 5.97 billion) every year (Wang, 2008). Among all cities, although Changsha, Zhuzhou, and Xiangtan are the heart of the economic, political and cultural life of Hunan Province, while the water qualities of the three cities were the worst. Thus, it is necessary to control pollutants and improve water quality of Xiangjiang. In recent years, the local governments have stepped in and appealed for action against pollution, for example, more than 400 heavy pollution corporations have been closed in 2000. Hunan government also has realized that a new model of industrialization and urbanization different from traditional development model and to establish a harmonious society with a resource-saving and environmentally friendly mode of development (named two-oriented society) should be build. In 2007, Chang-Zhu-Tan city cluster including Changsha, Zhuzhou, and Xiangtan (Figure 1) as comprehensive supporting reform testing zone of two-oriented society has been approved (He and Cao, 2009). Due to the construction of two-oriented society, Hunan government want to put 17.4 billion on improving the quality of Xiangjiang, and make it as "Chinese Rhine". However, the improving the quality of Xiangjiang is not only depended on the government, but also needed local residents' support, especially Chang-Zhu-Tan city cluster people.

Thus, to estimate how much people will be willing to pay for improving water quality, although, the contingent valuation method (CVM) is subject to severe criticism, however, due to a simple, flexible nonmarket valuation method (Venkatachalam 2004), this method is widely used and is considered a more appropriate method for evaluating the willingness to pay (WTP) of local residents (Geen et al., 1998; Amigues et al., 2002; Zhu and van Ierland 2012). Since it was introduced to China in 1980s, there were some literatures on CVM especially on assessment the fields of resource and environment in China (Du, 1996; Xue et al., 1999; Li et al., 2001; Liu et al., 2004; Zhang et al., 2004; Liang et al., 2005; Wang and Mullahy 2006). In the study, the objectives are to estimate the value of the improving water quality of Xiangjiang for Chang-Zhu-Tan city cluster residents; to evaluate the level of awareness of Xiangjiang valley residents about the quality of Xiangjiang in ensuring sustainable water supply; to determine their WTP for the improving quality of Xiangjiang; and to identify the factors that affects their willingness to pay (WTP).
Figure 1. The planning of Changsha-Zhuzhou-Xiangtan city cluster

2. Materials and Methods

2.1. The Study Area
The Xiangjiang is located between 110.5° E–114° E longitude and 24° N-29° N latitude. The river that is the largest river originating from Lanshan county, Yongzhou city, has a total length of 948 km, and its basin area is around 94721 km² (Ding and Zhou, 2013), and flows through six cities (Yongzhou, Hengyang, Zhuzhou, Xiangtan, Changsha, and Yueyang), and then enters into Dongting Lake which connects to the Yangtze River. The Xiangjiang basin covers only 40% of the total area of Hunan Province, while approximately 60% of the population lives along its banks, and it is responsible for 63.5% of the gross domestic product, and 80% of cargo transfer via water carriage occurs along the Xiangjiang (Zhang et al., 2014).

Among six cities along Xiangjiang, Changsha is the capital and the largest city, as well as the center of politics, economy, technology, culture and transportation, Zhuzhou is the second largest city and the largest industry city, and Xiangtan is the third largest city and an important industry and transportation center in Hunan province. Due to each two of them less than 40 kilometers, Hunan provincial government wanted to bring urban areas of the three cities together, namely Chang-Zhu-Tan City Cluster. For example, Hunan provincial government moved its office from the center of Changsha to the south in 2004, Changsha constructed the Furong Road to accelerate the link with Zhuzhou and Xiangtan, Zhuzhou built Zhuzhou Avenue to link with Xiangtan, and Xiangtan reconstructed Shaoshan Avenue and Bantang Avenue to link with Changsha. On 14th December, 2007,
Chang-Zhu-Tan City Cluster (longitude from 110°53’ E to 114°15’ and latitude from 26°3’ to 28°40’) with an area of approximate 28,088 km² has been approved by National Development and Reform Commission. In the early three years, three cities general production value of 243.07 billion Yuan takes up 39.3% of the province, import, export and actually employed foreign capital all over 60%. With the development of economy, the quality of environment has kept increasing as well as stable, for examples, Changsha has become the third State-level Forest City and Zhuzhou has eventually removed the bad reputation as one of the ten most air-polluted cities in whole country.

2.2. Sampling Procedure
The total number of households (n) to be included in the survey will be determined using the formula:

\[ n = \frac{N}{1 + N \times e^2} \]

Where \( n \) is sample size, \( N \) is the total number of households in the area, and \( e \) is the desired margin of error, 7% in the project. According to Hunan Statistic in 2010, the number of households in Changsha, Zhuzhou, and Xiangtan are 1877000, 785000, and 875000, respectively. With a desired margin of error of 7%, a total of 612 respondents (including 204 in Changsha city, 204 in Zhuzhou city, and 204 in Xiangtan city) will be included in the survey. According to the factor, a total of 660 containing 220 respondents were interviewed.

2.3. Survey and Data Source
The questionnaire used for the formal survey consisted of four parts: respondents' perceptions on information of Xiangjiang and its status of water quality and environmental issues; respondents' awareness regarding quality of drink water and human health; Chang-Zhu-Tan city cluster residents' willingness to pay, which is a key role in the survey; respondents' personal information and information on their families such as sex, age, education, income, and daily water cost.

In March of 2010, the 60 prequestionnaires were carried out in Changsha, Zhuzhou, and Xiangtan cities, respectively. These prequestionnaires showed that some respondents could not easily grasp the WTP. During a subsequent focus group discussion, participants were asked to explain why the survey was carried out. In early April, the questionnaire was adjusted, and then WTP method was limited avoiding zero pay.

In order to explain the status of Xiangjiang, both pictures on Xiangjiang before and treatment, the residents' WTP were asked, if the answer was "yes", the respondents were asked what payment method they would accept, and how much will be paid (among CNY 2.0, 5.0, 10.0, 15.0, 20.0, 30.0, and 50.0 Yuan, or US$ 0.3, 0.75, 1.49, 2.24, 2.99, 4.48, and 7.46 US$1=CNY 6.7 yuan), or the questionnaire stop.

The deep questionnaire was also asked for those who will pay whether pay again. If respondent say yes, how much was shown through choosing the card with money number, or the deep WTP stop.

2.4. Data Analysis
For the dichotomy methods, because the resulting data is the respondents YES or NO answer to the bid, so it should be established the function between the respondents' answer and the bid. The basic functions form can be used Logit function (1):

\[ Pi(\text{yes}) = 1 - \left[1 + \exp(\alpha + \beta Bids - \gamma X)\right]^{-1} \] (1)

Where, \( \alpha, \beta, \gamma \) are the regression coefficients of Logit function, \( X \) is a vector, assembled by the participants and participants in the tender value of the social characteristics variables. If the results of
respondents answered "Yes", then $I_y = 1$, $IN = 0$; if the results of respondents answered "No", the $IN = 1$, $I_y = 0$. The formula above log-likelihood equation can be expressed as following.

$$L = \sum_{i=1}^{N} \ln [I_y P_i(\text{yes}) + I_N P_i(\text{no})]$$

(2)

When $WTP \geq 0$, the formula of calculating expectation from the Hamemann equation (Hamemann, 1984) was described (3).

$$E(WTP) = -\frac{\alpha + \sum \gamma_k X_k}{\beta}$$

(3)

Where the $\beta$ is the effect coefficient with answering 'yes' to the maximum bid. If the regression equation does not have other independent variables effects, $\alpha$ is the constant. On the contrary, the $\sum \gamma_k X_k$ is the total sum between the other independent variables of regression coefficient multiplied and their average value.

The total of WTP (TWTP) was calculated the following equation:

$$T_{WTP} = WTP_a \times n \times N_h \times R_p,$$

(4)

Where $WTP_a$, $N_h$ and $R_p$ are WTP of a household, the total number of household and the ratio of who want to pay among total number of household, $n$ means a year, 12 months.

3. Results and Discussion

3.1. Sampling character

Among 660 questionnaires, 623 questionnaires including Changsha 204, Zhuzhou 208, and Xiangtan 211 were effectively indicating that the recovery ratio was 94.3%. While due to answer incompletely, refuse questionnaire, and mis-understand questionnaires, 37 questionnaires accounting for 5.7% were taken as invalidation.

The basic information of respondents from Changsha, Zhuzhou and Xiangtan was shown in Table 1. Among all respondents, the percentages of male and female were 44.94%, and 55.06%, respectively. This is because most of interviews were conducted in the daytime when the male work outside, while females were at home and kept house.
**Table 1** The basic information of respondents

| Variable       | ID | Property   | Sample | ratio(%) |
|----------------|----|------------|--------|----------|
| **Gender**     | 1  | male       | 280    | 44.94    |
|                | 2  | female     | 343    | 55.06    |
|                | 1  | 18-30      | 18     | 2.89     |
|                | 2  | 31-45      | 243    | 39.00    |
| **Age (years)**| 3  | 46-60      | 218    | 34.99    |
|                | 4  | ≥61        | 144    | 23.11    |
|                | 1  | without job| 47     | 7.54     |
|                | 2  | institution| 65     | 10.43    |
|                | 3  | company    | 94     | 15.09    |
|                | 4  | student    | 83     | 13.32    |
|                | 5  | officer    | 48     | 7.70     |
|                | 6  | free person| 74     | 11.88    |
|                | 7  | retired    | 105    | 16.85    |
|                | 8  | farmer or work| 107 | 17.17 |
|                | 1  | middle school or lower | 171 | 27.45 |
|                | 2  | high school | 205 | 32.91 |
|                | 3  | college    | 111    | 17.82    |
|                | 4  | university or higher | 136 | 21.83 |
|                | 1  | ≤15000     | 108    | 17.34    |
|                | 2  | 15001—40000| 235 | 37.72 |
| **Education level** | 3  | 40001—70000 | 120 | 19.26 |
|                | 4  | 70001—100000| 60  | 9.63     |
|                | 5  | ≥100000    | 100    | 16.05    |

There were four stages of age, 2.89% belonging to 18-30 years old, 31-45 years old accounting for 39.00%, 46-60 years 34.990%, and ≥61 years old 23.11%, indicating most of residents' age higher than 30 years old with society knowledge.

The occupation was divided into eight kinds such as without job (7.54%), institution (10.43%), company (15.09%), student (13.32%), officer (7.70%), free person (11.88%), retired (16.85%), and farmer or worker (17.17%).

The education degree was marked five levels like middle school (27.45%), high school (32.91%), college (17.82%), and university (21.83%), respectively.

The level of household income (CNY) per year was described five types such as ≤15000 (17.34%), 150001-40000 (37.72%), 40001-70000 (19.26%), 70001-100000 (9.63%), and ≥100000 Yuan (16.05%), indicating 55.06% of residents' income were lower than CNY 40000 Yuan

### 3.2. Information on Xiangjiang

Do you know Xiangjiang is one of important rivers in Hunan province? The survey showed that about 96.3% of responders realized that Xiangjiang is Hunan's mother river, while 4.7% didn't know.

Do you often visit Xiangjiang? The survey showed that over 80.6% said yes, 14.0% visited occasionally, while 3.4% visited only once in a year or in a lifetime. The major purpose of repeat visitors was walking, jogging, swimming or boating activities, which were either highly localized or seasonally concentrated.

What's your opinion on environment quality of Xiangjiang? About 12.2% of responders considered water quality good and 1.3% didn't know, while more than 86.5% believed it bad or very bad, which demonstrate that most the visitors were unhappy with the water quality of Xiangjiang.

Which polluter is the dominative problem among environment pollution in Xiangjiang valley? About 94.8% thought the water pollution was serious, followed by solid waste pollution.
Do you think that it is necessary to take measures to treat Xiangjiang pollution? Among all of responders, 99.3% choose yes, while 0.7% said no need.

Do you know Hunan government will spend CNY 10 billion Yuan (US$ 1.49 billion) on improving water quality of Xiangjiang? Do you support the 'Chinese Rhine' project? Among all of responders, 97.8% know and want to support the project, while, 2.2% don’t know and don't support.

3.3. Effect of water quality on human health
During the interview, about 87.0% responders’ drinking water from Xiangjiang in their daily lives in three cities, and 13.0% families buy bottled water from market.

In the survey, 92.3% citizens thought that the drinking water is unsafety. If the drink water was contaminated, over 90.0% responders would appeal to local government, department of environment and news media. While, 7.7% persons thought it was fine, and about 10% don’t know how to do when drinking water contaminated.

About the relationship between health and drinking water, 85.1% residents said their health were caused by the bad quality of drinking water, while 14.9% felt fine.

In a word, most of Chang-Zhu-Tan city cluster resident have paid more attention on water quality of Xiangjiang, and realized that it is necessary for their lives, agriculture, and industry to improve water quality of Xiangjiang.

3.4. Controlling Xiangjiang Pollution
In the process of survey, both pictures on water quality of Xiangjiang before and after treatment were shown to those responders. Most respondents did understand completely what were introduced to them, like the truth of Xiangjiang pollution, economy loss due to pollution, and cost of improving water quality. The results showed that 97.3% of residents hope that the water quality of Xiangjiang would be improved, while average 70.1% including 70.6% in Changsha, 70.2% in Zhuzhou, and 69.7% in Xiangtan, wanted to pay for improving water quality of Xiangjiang.

3.5. Willingness to Pay
The distribution of WTP of Chang-Zhu-Tan residents was shown in Figure 2. It can be seen that the general trend of WTP decreased with increasing bidding value. The lowest probability for acceptable was 16.0% at the maximum bid value CNY 50.0 Yuan, indicating that 84.0% respondents would not pay more than CNY 50.0 Yuan. However, the highest acceptance of the tender value was not the minimum bid value CNY 2.0 Yuan (95.83%), but was CNY 5.0 Yuan accounting for 97.00%. Maybe most of residents thought CNY 2.0 Yuan was so little to do nothing, while CNY 50.0 Yuan was beyond their capacities, so they selected CNY 5.0 Yuan. There 437 residents among 623 responders accounting for 70.1% showed their WTP for improving water quality of Xiangjiang. In other studies, the ratios of WTP were 73.6% (Hu et al., 2009), and 66.4% (Li et al., 2001). While 186 residents accounting for 29.9% refused to pay, meaning 29.9% of zero-WTP.
According to the equation (1), (2), and (3), the regression analysis table of participants' WTP under single-bounded dichotomous CVM was shown in Table 2. The calculating expectation of WTP was CNY 24.54 Yuan per month for 437 responders, which means the CNY 17.18 Yuan per household and per month (also CNY 206.16 Yuan per household and per year) as the average WTP for 623 interviewers. Comparison of some Chinese studied, the residents' WTP were shown that 143 Yuan (Li et al., 2001), 158.97 Yuan (Xu et al., 2003), 195.07-253.04 Yuan (Zhao et al., 2005), 100.66 Yuan (Cai et al., 2006), 191.65-260.00 (Hu et al., 2009), and 127.00 Yuan (Zhang et al., 2009).

Table 2. Definition and variable of Logistic model

| Variable                | Definition                                                                 | Coefficients | Average |
|-------------------------|---------------------------------------------------------------------------|--------------|---------|
| Whether Support government | Whether the respondents support the government invested fund to improve the water quality of Xiangjiang River. 1 = Yes; 0 = No | 1.032*       | 0.98    |
| Attitude to the water quality | The respondents' attitude to the water quality. 1=considered unsafe; 2=just so so; 3= safe | -0.205       | 1.76    |
| Sick history | Whether the respondents' family had appeared ill for the unhealthy drinking water. 1=Yes, they had; 2=No, they hadn't. | -1.102       | 0.04    |
| Gender | Male=1; Female=0 | 0.857** | 0.46    |
| Education | 1=middle school or lower; 2=high school; 3=college;4=university or higher | -0.066       | 2.42    |
| Annual income(CNY) | 1=≤15000; 2=15001-40000; 3=40001-70000; 4=70001-100000; 5=≥100000 | 0.234*       | 2.48    |
| Bidding value (CNY, β) | 2.0, 5.0, 10.0, 15.0, 20.0, 30.0, and 50.0 | -0.108**     | 1.229   |
| Constant (α) | | | -150.10 |

Log-likelihood function

Attention: *p<0.05, and **p<0.01

According to Chinese sixth population general survey (Statistical Bureau of Hunan, 2011), the total number of households was 4,110,927 in Chang-zhu-tan city cluster, including Changsha 2,121,722, Zhuzhou 1,161,328, and Xiangtan 827,877. Then the total of WTP calculated with equation (4) was 0.848 billion (US$ 0.127 billion).
3.6. Effects on WTP
In the survey, some factors such as bid value, gender, household income, education level, age, occupation, and environmental awareness were shown in Table 3. It can be seen that there was the negative correlation between the tender value and WTP (p<0.01), which means higher tender value, less WTP. There was significant positive correlation between gender with WTP (p<0.01), indicating that man wanted to pay more money than that of woman. Because man were more care about social news, economic development, and environment protection than woman. Household income had a significant positive correlation with WTP (p<0.05), indicating that the more household income, the more WTP. However, as for other factors such as education level, age, occupation, environmental attitude, there were no significant effect on WTP (p>0.05).

| Variables                      | B       | Wald-test df | Exp(B) |
|--------------------------------|---------|--------------|--------|
| Bidding value                  | -0.110**| 64.522       | 0.896  |
| Age                            | -0.177  | 1.311        | 0.838  |
| Gender                         | 0.918** | 8.501        | 2.504  |
| Education level                | -0.124  | 0.775        | 0.884  |
| Household income               | 0.226*  | 2.818        | 1.254  |
| Attitude to the water quality  | -0.217  | 0.905        | 0.805  |
| Sick history                   | -1.145  | 2.492        | 0.318  |
| Xiang River proximity          | 0.029   | 0.021        | 1.029  |
| Constant                       | 1.700   | 1.342        | 5.476  |

Attention: *p<0.05, and **p<0.01.

3.7. Reason of refusal
The investigation showed that 29.9% refused to pay for improving water quality of Xiangjiang. There are five reasons. Firstly, there 35.88% of responders thought the government should pay for the treatment Xiangjiang pollution, not them. Because, the government should improve environment quality of water by their tax income. Secondly, about 23.85% thought that Chinese rule of environment protection is "Who pollute, Who pay", so the all enterprises along Xiangjiang valley should pay, not them. Thirdly, they doubt whether the money is real for improving water quality of Xiangjiang accounting 20.3%. Fourthly, some residents with financial problem accounting for 11.47% so that they could not support. Fifthly, a few residents accounting 8.5% did not care about water quality of Xiangjiang.

4. Conclusion
In the survey, it is found that most of residents know about Xiangjiang, as mother river of Hunan province very well, and often visited her. While with the development of industrialization and urbanization, a lot of environment problems especially water pollution had happened in Xiangjiang. Most of respondents are aware of correlation between water quality and their health, and 70.1% among all of respondents hope to improve water quality of Xiangjiang pollution with CNY 17.18 Yuan (US$ 2.56) per month per household, and the total economic value was CNY 0.848 billion Yuan (US$ 0.127 billion) for Chang-Zhu-Tan city cluster. It was heavily dependent on bid value, household income, education level, age, occupation, and environmental awareness and so on. The positive effect of gender and average income of residents', while negative effect of bid value on willingness to pay for improving water quality of Xiangjiang were significantly.
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