Measuring the willingness to pay for drinking water quality improvements: results of a contingent valuation survey in Songzi, China

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ABSTRACT

The aim of this study is to elicit local residents' willingness to pay (WTP), by applying the contingent valuation method as a surcharge on their water bill, for a given improvement in the drinking water quality and the supply reliability. The mean WTP for the drinking water quality improvement program was estimated to be 16.71 yuan (0.3% of total household income). The results note that more educated respondents and households with higher income and with fewer household members are, on average, willing to pay more. This study also demonstrates that respondents' concerns regarding drinking water quality and perceptions of the health risk of drinking water quality can have significant positive impacts on people's WTP. The research results can help decision-makers understand the local population's demand for improved drinking water quality and undertake an environmental cost–benefit analysis.

Key words | contingent valuation method, drinking water quality, Songzi, willingness to pay

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INTRODUCTION

Helping people gain access to safe drinking water is one of the most important health-related infrastructure programs in the world (Zhang 2012). There are nearly one billion people worldwide who rely on unimproved sources of drinking water that are not protected from contamination and that may cause illness or death (WHO/UNICEF 2010). Furthermore, the World Health Organization estimates that 83% of households use improved drinking water sources that have been contaminated, either at the source or during collection, storage, and handling (WHO 2005). Rural areas are particularly vulnerable; eight out of ten people continue to have no access to safe drinking water. Currently, people have become increasingly concerned about their health and have developed an interest in the safety of drinking water (Kwak *et al.* 2013).

After decades of high-speed economic growth, China is encountering a bottleneck caused by water deficiency and huge pollution. Water was accorded a top priority and preferential treatment during the formation of the 12th Five-Year plan (2011–2015), which is the extremely important national development plan stipulated by China's central government every 5 years. Currently, special attention is accorded to improving the quality of the water delivered. In July 2007, China adopted a new national standard for drinking water quality to ensure a clean tap water supply to the country's urban and rural residents. From the economic theory perspective, it is important that such decisions be undertaken within a framework that evaluates both the benefits (from the customers' perspective) and costs of the proposed higher standards. This paper focuses on the perceived values associated with the changes in drinking water quality and in water services from the perspective of consumers.

The value a household places on a change in the supply of a good can be inferred from its present behavior through the choices the household makes, but also through the stated choices a household declares when confronted by a hypothetical scenario of a supply change. As a survey-based method that directly elicits respondents' willingness to pay (WTP), the contingent valuation method (CVM) is considered to be

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an appropriate method for valuing water quality improvements or other services, because the value of water quality improvements includes not only on-site use value but also non-use value (Wang *et al.* 2013). The underlying idea of the CVM is that people's preference-related value of non-marketed environmental goods (the improvement of drinking water quality, in this case) can be revealed if appropriate questions are requested in a hypothetical market questionnaire survey (Mitchell & Carson 1989; Jakobsson & Dragun 2001; Bateman *et al.* 2002; Carson & Groves 2007; Frör 2008).

Some examples of studies that have elicited respondents' preferences for the policy on drinking water quality improvements by determining their WTP are provided by Jalan *et al.* (2003), Hensher *et al.* (2004), Atkins *et al.* (2007), Genius *et al.* (2008), Akram & Olmstead (2010), Kwak *et al.* (2013), and Tussupova *et al.* (2015). Although the CV method has been used to estimate the economic value of water quality improvements in Western countries, its application in developing countries remains very limited (Wang *et al.* 2013). To the best of our knowledge, there is no published work on estimating households' WTP for drinking water quality improvements in China. Moreover, due to cultural and socioeconomic differences, the level of WTP can differ among different regions. Case studies for many regions are needed, and the results of the studies can then be compared (Kwak *et al.* 2013). In this study, we focus on measuring the economic benefits of tap water quality improvement in Songzi, China. This study is expected to contribute to the literature in that it is one of the few rigorous attempts to evaluate the economic value of the drinking water quality improvement projects in developing countries, where the results can be dramatically different from those obtained in the developed world.

The remainder of this paper is organized as follows. The second section presents the research design. The results of the empirical research are presented in the third section. The final section contains concluding remarks.

RESEARCH DESIGN

The study area

Songzi is located in the southwest of Hubei Province. The area of this county is approximately 2,235 km^2, and it has a total population of 850,000. Of the population, 80% live in rural areas, where approximately one-third of households have piped access to the local water distribution. In recent years, Songzi has endured drought, algae blooms, and industrial and agricultural wastewater pollution, which all posed a great threat to the drinking water for rural residents. Since 2007, the Songzi Municipal Government has invested a large amount of money to build 'safe drinking water projects' in rural areas. However, the quality of drinking water remains unsatisfactory. A recent study by a local university (Wang *et al.* 2011) took samples from the central water supply as well as from several discrete sources in the countryside and found that most water quality indicators exceeded Chinese national standards. The study concluded that water in rural Songzi was not safe for drinking. In view of the above, the local authorities have the incentive to provide a better water supply to rural families. However, to help policy-makers make more efficient decisions and to expedite the process, consumers' opinions and their WTP for improved drinking water quality should be studied (Tussupova *et al.* 2015). Thus, the purpose of this paper is to determine whether rural residents in Songzi are willing to pay for a given improvement in the drinking water quality and the reliability of supply.

The dichotomous choice CVM

For this CVM study, the single-bound dichotomous choice (DC) method is employed. The DC approach was first employed by Bishop & Heberlein (1979) to measure the economic value of goose hunting. Respondents in the DC approach are requested to accept or reject a suggested price under a hypothetical market situation. When presented with a bid, respondents need to answer 'yes' or 'no'. It is easier for respondents to answer DC questions than open-ended questions because they are familiar with discrete choices in market transactions (Hanemann 1994). In this respect, the DC format is generally considered to be a superior elicitation method (Lee & Mjelde 2007).

The survey instrument

In accordance with standard guidelines (Arrow *et al.* 1993; Bateman *et al.* 2002; Mitchell 2002), the CV survey instrument

was carefully designed to provide respondents with adequate and accurate information based on a series of focus group discussions conducted among the authorities and enterprises involved in drinking water quality management and control, certain environmental experts, and local residents. Discussions were conducted around the perceptions and attitudes toward local economic and environmental situations, the improvement of drinking water quality, as well as possible payments for the improvement. A series of pre-testing surveys were also conducted to further identify and correct potential problems. Consequently, questions that were poorly understood were modified for clarity.

The questionnaires finally adopted in the survey included four parts. The first part focuses on the attitudes and perceptions of the respondents towards the general environmental issues. The second part encompasses questions related to drinking water availability, people's perceptions and attitudes towards drinking water quality, whether the household treated water, and the cost of the current service bundle. To assess the level of perceived health risk of drinking water quality, respondents were requested to rank the perceived risk on a five-point Likert-type scale (from 1 to 5) as follows: 1 = no risk, 2 = small risk, 3 = medium risk, 4 = high risk, and 5 = extremely high risk.

The third part evokes households' WTP for a program to improve tap water quality. Respondents were first presented with the current drinking water quality situation in Songzi. Then a program was introduced that targets improving the drinking water quality and the reliability of supply. Respondents were told that the improved tap water will be reliable and safe to drink without further treatment. That was followed by the WTP questions and certain debriefing questions, such as respondents' reasons why they were or were not willing to pay. Based on the results obtained in the focus groups and pre-test surveys, five different bids were established: 2, 5, 10, 20, 40 yuan (yuan is Chinese currency, 1USD = 6.1 yuan). Each respondent was presented with a single randomly assigned dollar amount. The payment vehicle used for this study was an extra surcharge on respondents' household monthly water bill, with which most respondents are likely to be familiar. Several previous studies such as those of Saz-Salazar *et al.* (2009), Ramajo-Hernández & Saz-Salazar (2012), and Kwak *et al.* (2013) also used water bills as a payment vehicle.

The last part collects the respondents' socioeconomic information. The purpose of these questions was to obtain information regarding the respondents' age, gender, educational attainment, the number of people they usually live with, and income.

Sampling and data collection

Because this study is focused on the benefits of tap water quality improvement, only those households with a tap water connection were investigated. To create representative samples of the designated area, a multiple-stage stratified random sampling approach was adopted. The sample sizes were determined to be proportional to the population sizes of different categories.

The survey was administered to heads of households or to housewives whose ages ranged from 20 to 70 years. The head of household or the housewife was the person with the primary responsibility for providing food and care to the members of the household. These individuals can be well aware of the overall income and expenditures of the household and can make decisions regarding additional expenditures for the household.

The enumerators involved in this study were specially trained, following the principle that appropriate enumerators make respondents feel comfortable and at ease (Bateman *et al.* 2002; Whittington 2002). To provide the greatest scope for detailed questions and answers in this study, we chose to use face-to-face interviews for the CV survey. The interviews were conducted in the respondents' homes. Explanations were provided when needed. At the end of each field day, field coordinators checked the returned questionnaires for completeness and accuracy according to a quality checklist.

EMPIRICAL RESULTS

From June to August 2011, interviews were administered to the randomly selected households by six well-trained interviewers. The interview time was approximately 40 minutes on average. After discarding 32 questionnaires, which were incomplete or considered as outliers, a total of 168 sampled households provided valid responses, resulting in

a response rate of 84%. A token gift was offered to the respondent as appreciation for participating in the interview when they completed the survey (Chen 2015).

Socioeconomic characteristics of the respondents

Table 1 provides a summary of certain socioeconomic characteristics of the sample. The sampled population is aged between 20 and 70, with an average age of 52 years. Thirty-seven percent of the respondents were male, and approximately 89% were married, due in part to the fact that many men and young single people had chosen to seek jobs in urban areas when we conducted the survey. The average educational level was immediately above the elementary school level. Specifically, approximately 15% had no formal schooling, and 35% had finished elementary school; in addition, 47% had finished middle school. The average household income is approximately 3,373 yuan/month (562 USD/month). With regard to the education and income variables, the sample appears approximately representative of the general population in Songzi. All households interviewed had working water meters and received their bills on a regular basis. The household water bill was approximately 3.91 USD per month on average.

Respondents' perception of drinking water quality

Respondents were requested to indicate the most serious water problems in Songzi. The results were that approximately one-fifth of our respondents regarded the poor drinking water quality as the most serious water problem.

Respondents were asked whether the water from the tap was safe to drink without further treatment. Of the respondents, 12% thought that their tap water was safe to drink. One issue further investigated through the questionnaire was whether citizens drink tap water without any further treatment. According to the results of the study, most respondents (95%) stated that they never drank tap water directly. The participants reported having had to treat their tap water before drinking, usually by boiling. This behavior is a huge departure from what local authorities and international non-governmental organizations (NGOs) would generally expect to observe among pipe-water connected households, under the presumption that piped water networks should provide safe drinking water without the need for further treatment at home. When respondents were asked whether they thought that their tap water was treated at the source, 28% of respondents said yes. Most remaining respondents did not know whether the local water distributor treated their water.

Respondents were requested to indicate what they liked least regarding the water service from their piped water system. The results from our survey show that nearly half of them (45%) did not like the water quality. Approximately 17% of respondents complained that the water services were always broken. Other complaints included the high monthly water bill and having less than 24-hour service.

The mean risk perception index for the sample surveyed in this study was calculated at 2.62 based on a score scale from 1 to 5. This result shows that the level of respondents' perceptions of the health risk of drinking water quality is approximately medium.

Table 1 | Descriptive statistics of respondents' socioeconomic characteristics

Variable	Definition	Mean	Std. Dev.	Min	Max
Gender	Binary variable, 1 if respondent is male; 0 otherwise	0.37	0.48	0	1
Age	Age of the respondent	52	11	20	70
Marriage	Binary variable, 1 = married; 0 = otherwise	0.89	0.32	0	1
Education	Education of respondents (1 = No formal schooling, 2 = Elementary, 3 = Middle school, 4 = College, 5 = Master's or above)	2.47	0.93	1	5
Hhsize	Number of household members living together	4.61	1.71	1	10
Kid5	Number of children less than 5 years old	0.27	0.45	0	1
Hincome	Household income (yuan/month)	3,373	2,730	500	12,000

Respondents' attitudes towards payment

Regarding the intention of individuals to contribute a certain amount for the improvement of drinking water quality, approximately 54% of the sample stated a positive answer. This result shows that there was a demand to improve the drinking water quality in Songzi. Frequently selected reasons for saying 'yes' to the WTP question are shown in Table 2. The most important reason for stating a positive WTP was the respondents' belief that better water quality is good for health. A number of respondents (24%) believed that drinkable tap water is more convenient, and a few respondents (9%) believed that this project can provide better living conditions for future generations.

Concerning the reasons for refusing to pay, the most common reason was that the respondents could not afford the amount (44.8%) (see Table 3). Of the sample, 15.4% stated that there was no need to drink water directly. These responses were regarded as true zeros. Five respondents said it was the government's responsibility to pay the cost, and 11 respondents provided other reasons, such as they disliked the program. These responses were regarded as protests (see Jorgensen *et al.* 1999; Jorgensen & Syme 2000).

Table 2 | Frequently selected reasons for 'Yes' WTP answer (%)

	Response	
Reasons	**No.**	**Percentage**
Better water quality is good for health	60	65
Drinkable tap water is more convenient	22	24
This project can provide better living conditions for our future generations	8	9
Others	2	2

Table 3 | Frequently selected reasons for 'No' WTP answer (%)

	Response	
Reasons	**No.**	**Percentage**
I cannot afford that amount	34	44.74
I am not interested in this improvement project	12	15.79
There is no need to drink tap water directly	15	19.74
It should be the government's responsibility	5	6.58
Others	10	13.16

Empirical estimation results

Data from contingent valuation surveys represent respondent evaluations of a hypothetical market rather than observations of actual economic transactions. This behavior creates a concern when using contingent valuation data regarding whether the data on which results are based follow the basic premises of consumer theory, such as falling demand with price. One advantage of a nonparametric analysis of contingent valuation data is that the response to price can be directly observed in the data. The nonparametric technique for analyzing respondent WTP is to develop survivor curves showing the likelihood of agreeing to make the requested (hypothetical) payment as a function of the bid requested, that is, as a function of how much the respondent is requested to pay. Thus, for each bid that was requested, we can calculate the percentage of respondents who were willing to pay the requested bid. The survivor curve obtained from this study is shown in Figure 1. In agreement with the economic theory of demand, the 'yes' response monotonically decreases (increases) as the offer amount increases (decreases), indicating that a higher bid would result in a lower probability of saying 'yes' to the WTP question.

The DC CVM has a binary choice dependent variable that requires a qualitative choice model. The probit and logit models are commonly used to model 'yes' or 'no' responses to relevant socioeconomic variables and other variables (Ninan & Sathyapalan 2005). The logit model is used in this study because it is preferred to the probit model in many fields due to its relative computational simplicity (Lee 1997). The probability that the individual will accept an offer A can be expressed using the following logit model (Hanemann *et al.* 1991):

$$P_i(yes) = F_\varepsilon(\Delta V) = \frac{1}{1+\exp(-\Delta V)} = \frac{1}{1+\exp[-(\alpha+\beta A+\gamma s)]}$$

where α, β, and γ are coefficients to be estimated; A is the dollar amount that the respondent was requested to pay,

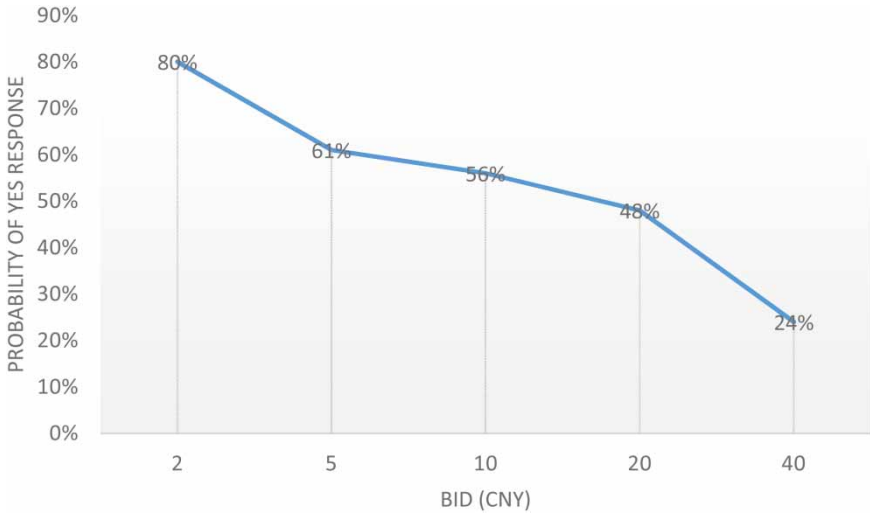

Figure 1 | The survivor curve.

and *s* may include responses to attitude questions or to the respondent's demographic information, such as age, education, and income.

In this study, the dependent variable in the logit model was the probability that the respondent would be willing to pay for the drinking water quality improvement program. The explanatory variables included the bid amount, the respondents' perceptions of the drinking water quality, and certain demographic and socioeconomic variables. The definitions of those explanatory variables included are shown in Table 4.

Table 4 | Definitions of explanatory variables in the logit models

Variable	Definition
Bid	The bid used
Gender	Dummy variable: 1 = male; 0 = female
Age	Age of the respondent
Dwimportant	Dummy variable: 1 if respondents think drinking water quality is important; 0 otherwise
Healthrisk	Category variable to indicate respondents' perceptions on the health risk of drinking water: 5 = extremely high; 4 = high; 3 = medium; 2 = small; 1 = no risk
Education	Category variable: 1 = No formal schooling; 2 = Elementary; 3 = Middle school; 4 = College; 5 = Master's or above
Hhsize	Number of household members living together
Hincome	Total household income (1,000 yuan/month)

The results of the models are summarized in Table 5. The results suggest that the estimation model has a high predictive power and statistical reliability. As shown in Table 5, most explanatory variables are statistically significant at 10% or lower. The *chi*-square result shows that the likelihood ratio statistic is highly significant ($P < 0.001$), suggesting that the model has strong explanatory power.

Table 5 | Factors affecting respondents' WTP

Variable	Coef.	Std. Err.	*t*-statistics	*P*-value
Constant	−0.01	1.57	0.00	0.996
Bid	−0.07***	0.02	−4.54	0.000
Gender	0.22	0.40	0.57	0.572
Age	−0.03	0.02	−1.33	0.183
Dwimportant	0.89**	0.40	2.23	0.026
Healthrisk	0.52***	0.20	2.56	0.010
Education	0.48*	0.26	1.88	0.061
Hhsize	−0.22*	0.13	−1.66	0.098
Hincome	0.19**	0.09	2.20	0.028
Summary statistics				
Log likelihood	−88			
Prob > chi^2	0.000			
Pseudo R^2	0.24			
Observation	168			

*significant at $P \leq 0.1$.
**significant at $P \leq 0.05$.
***significant at $P \leq 0.01$.

The pseudo R^2 value cautiously indicates how the logit model fits the data set (Menard 2002). The pseudo R^2 in this model is higher than the 20% level suggested by Louviere *et al.* (2000) as indicating a very good fit for these type of data.

As expected, the parameter on 'Bid' (price bids) was negative and significant at the 1% significance level. This result indicates that the respondents were less inclined to say 'yes' to the WTP question if they were presented with a higher bid amount. This result also confirms the findings of the nonparametric estimation approach and is consistent with the economic demand theory.

Our results show that respondents' perceptions of the health risk of drinking water and their beliefs of the importance of drinking water quality have significant effects on respondents' WTP. The coefficient on 'Dwimportant' is positive and significant at the 5% significance level, implying that a respondent who is more concerned about the drinking water quality would be more likely to say 'yes' to the given bid. In addition, respondents' perceptions of the health risk of drinking water quality were also a critical factor influencing people's WTP. The coefficient associated with this variable 'Healthrisk' was positive and significant at the 1% significance level, suggesting that respondents who perceived a higher health risk of drinking water quality would contribute more to the improvement program.

The coefficient of education (the respondent's level of education) was positive and significant, implying that a respondent with a higher educational level would be more likely to support the drinking water quality improvement program. This finding is consistent with empirical findings (Wang *et al.* 2013). As expected from the literature, the variable 'Hincome' (household income) had a positive and statistically significant impact on the respondents' WTP. This result indicated that a household with a higher income would have a greater WTP for the drinking water quality improvement program. This finding is in agreement with a priori expectations from economic theory, thus serving as evidence of the validity of this CVM study and its WTP estimates (Mitchell & Carson 1989; Bateman *et al.* 2002). The coefficient of Hhsize (the respondent's household size) was negative and significant. This result suggests that a respondent with a larger family would have a lower WTP for the improvement program. One possible explanation for this finding is that a larger family may have more expenditures on other things.

Benefit estimation

Based on the Hanemann's random utility maximization model (Hanemann *et al.* 1991), the mean WTP can be estimated from the regression results. To obtain a conservative estimate, we assumed that the non-respondents and protest respondents had a zero WTP. After adjusting for the non-respondents and protest responses, the mean WTP for the drinking water quality improvement program based on the logit estimation results was estimated at 16.71 yuan (2.78 USD) per household per month, approximately equivalent to 0.3% of the average household income.

The total benefits of the drinking water quality improvement program in Songzi were estimated by aggregating the mean WTP value to obtain a total WTP amount. This analysis was based on the simple transferring point estimate approach (Jin *et al.* 2008). With 148,755 rural households in 2011, the total benefits of drinking water quality improvement were estimated at approximately 29.83 million yuan (4.97 million USD) annually.

DISCUSSION AND CONCLUSION

The main objective of this study is to obtain empirical estimates of the willingness-to-pay for a given improvement in the drinking water quality and in the reliability of supply in rural China using the CVM. Our results show that there was a demand for an improvement in the drinking water quality. The mean WTP of the local population for the improved drinking water quality program was estimated to be 16.71 yuan (2.78 USD) per household per month, which is equivalent to 0.3% of the average household income. The WTP elicitation was within the respondents' abilities, and the mean WTP estimate was statistically significant. The WTP increases with income and education, as expected, and is positively related to respondents' perceptions of the health risk of drinking water quality and values of the importance of drinking water quality.

Our CVM estimate has passed a minimal test of theoretical validity (Saz-Salazar & Pau 2008). This study

demonstrated the applicability of the CV method to the issue of drinking water quality in rural China. Our findings can help improve our understanding of the local public's preferences for drinking water quality and can be used to help local policy-makers to design more efficient strategies for drinking water quality improvements in rural areas.

Although this study demonstrated reasonable results, we need to recognize that our results are based on a relatively small sample. Although small sample sizes have been used to effect (Castillo & Pitfield 2002), it must be acknowledged that the larger the sample size is, generally the more robust the conclusions. Moreover, we should be aware that the mean WTP based on the CV method was hypothetical rather than actual. Certain studies have indicated that individuals would overstate their WTP in a hypothetical market (Carlsson & Martinsson 2001). A validating study is needed to test whether the hypothetical WTP differs from the actual WTP. Finally, this study is the first known CV study that relates to the issue of drinking water quality improvement in rural China. More studies with alternative methods should be conducted to confirm the findings of this study for better policies.

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