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Contents

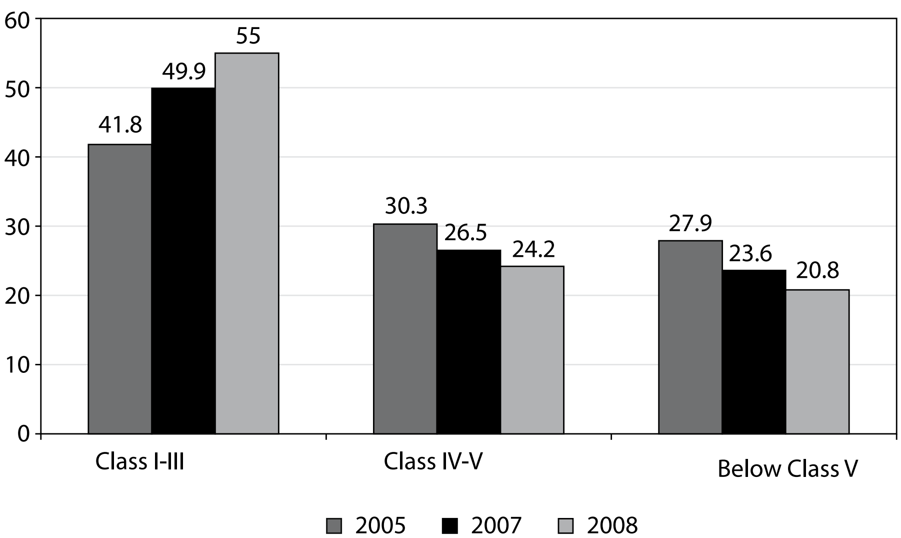
Abstract

Upstream nonpoint source pollution has become a significant threat to urban drinking water safety in the People's Republic of China. Payment for environmental services (PES) is seen as a promising mechanism to deal with the situation. In designing a sound PES, it is crucial to determine the willingness to pay (WTP) of urban beneficiaries for upstream water pollution controls. An analysis of household data from a contingent valuation survey conducted in Fuzhou in 2009 reveals that household income is the most important factor in determining respondents' positions on water tariff increases as well as WTP under a PES scheme. Mean WTP varies from Yuan (CNY) –0.45 per cubic meter to CNY0.86 for different income groups. The overall mean WTP is estimated to be CNY0.21, which is equivalent to a 10% increase in the current tariff, with the 95% confidence interval at (CNY0.12, CNY0.31). The point estimate implies a total annual WTP of Fuzhou City equal to CNY22 million, which is 27% less than the contribution of Fuzhou to an ongoing government-financed PES. However, with continuous water tariff increases, affordability among low-income households might arise as an issue. This calls for subsidies targeting low-income households to be incorporated in water tariff reform.

I. Introduction

Water pollution has emerged as one of the most serious environmental problems facing the People's Republic of China (PRC). It threatens human and ecosystem health, increases water treatment costs, exacerbates water scarcity, and ultimately will constrain the sustainability of the country's development. The results of monitoring more than 400 river sections around the country suggest that overall water quality remains poor, despite some moderate improvements in recent years (Figure 1). By 2008, water quality in 45% of the monitored river sections was below class III, making them ineligible for drinking even after treatment, and 21% were too polluted for any use.[1] Annual surveys since 2006 have found that over one-quarter of drinking water sources in key cities have failed to meet standards.

Figure 1: River Water Quality in the PRC, 2005–2008 (percent)



Source: Meng and Xi (2009).

While water pollution is recognized as a top issue, most attention is given to stationary industrial polluting sources and domestic sewage discharge. Agricultural pollution—the largest source of surface water pollution (Zhang et al. 2009), consisting of nonpoint

1 Environmental Quality Standards for Surface Water (GB 3838-2002) defines water quality in five classes in the PRC. Classes I-III are water safe for human consumption after treatment; IV-V are water safe for industrial and irrigation use; and class V+ is unsafe for any use (PRC EPB 2002).

sources such as animal waste, and often located at upstream sources—remains unchecked and is generally out of control. As such, it represents a significant challenge to water pollution control in that upstream towns and villages and downstream cities are at different stages of development and have distinct development goals. Upstream towns and villages, which are often poor and lack income sources other than agriculture, prioritize improving agricultural production over preserving river water quality. Wealthier, more populous downstream cities increasingly demand clean air and water as well as other environmental amenities. Upstream pollution of the water sources jeopardizes downstream residents' access to safe drinking water.

Tension between upstream and downstream areas is therefore common in the PRC and in other countries. But the polluters-pay principle may not be appropriate in dealing with the nonpoint sources, both because the polluters have legitimate rights to develop, and because tremendous implementation and enforcement costs may arise when applying command-and-control measures or pollution levies.[2] Alternative policy instruments are desirable that align the incentives of both parties and offer the needed upstream help for making changes.

Payment for environmental services (PES) is one such instrument.[3] PES is an arrangement in which those who benefit from environmental services make payments to the service provider(s) to compensate for their efforts or foregone benefits. PES improves economic efficiency by creating voluntary market transactions to internalize the external benefits of environmental services. Environmental services amenable to PES schemes include watershed protection, forest and pasture conservation, biodiversity and species habitat preservation, and so on. In the case of watershed protection and upstream pollution control, the budget of the downstream cities and/or additional funds collected from water users' bills generally finance the payments. They are made when the environmental service is secured, such as when water quality improves to a certain level at pre-agreed locations.

Fuzhou City, at the downstream end of the Min river basin, and the upstream municipalities of Nanping and Sanming, provide a typical setting for studying PES. The Min River runs from the western mountainous areas of Fujian province eastward down into the East China Sea. It is the main source of drinking water for Fuzhou City's 2.3 million people. As the provincial capital, Fuzhou has an industrialized and diversified economy, while Nanping and Sanming are less developed, with a large number of villages and towns heavily reliant on livestock farming. Nanping alone hosts over 480,000 livestock farms and the business has been growing in both municipalities. Without proper discharge treatment, these livestock farms, especially the large ones, are the most important contributors to Min River pollution. As of 2003, the percentage of water graded class III or above in the Min River dropped to 83% from 96% in 2001 (Figure 2).

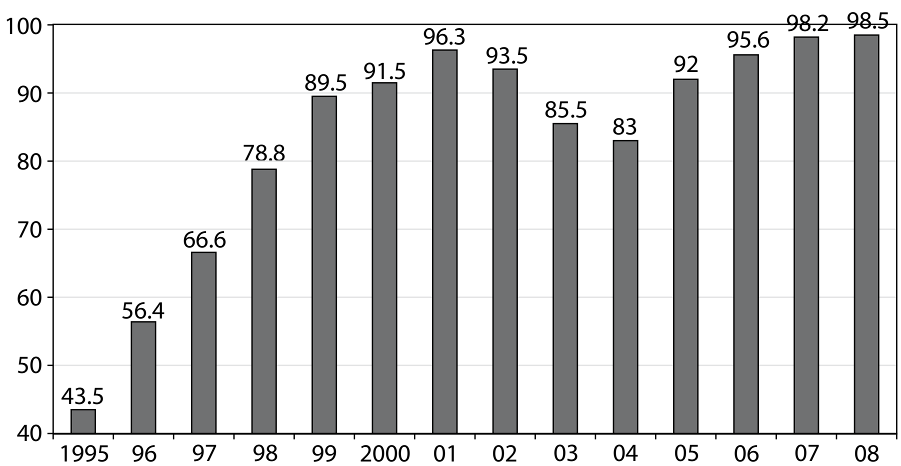
2 Liang et al. (2005) found that the majority of farmers living around the Miyun reservoir—Beijing's water source—were willing to pay nothing or very little for reservoir environmental protection.

3 The "E" in PES stands for environmental, ecological, or ecosystem in the literature. The concepts are close enough so we do not make any distinction.

According to an official survey, 63% of Min River pollution in terms of chemical oxygen demand load and ammonia nitrogen load can be attributed to livestock pollution (Fujian EPB 2005).

The Fuzhou government was faced with two options.[4] One was to seek alternative water sources aside from the Min River, although past experience suggested this could be prohibitively expensive. Fuzhou introduced water from the Ao River in the late 1990s to supply one-twelfth of its population living in Mawei and neighboring districts. But the project had cost CNY690 million, resulting in considerably higher water supply costs than from the Min River. The government therefore chose the second option: to finance upstream pollution control and reduction by building and operating waste treatment facilities for livestock farms. In 2005, it joined the Min River Environmental Protection campaign launched by the Fujian provincial government,[5] featuring a pilot PES program financing pollution control in Nanping and Sanming, particularly livestock, with a total of CNY50 million each year. The Fuzhou government contributed CNY10 million to the program, raising its contribution to CNY30 million in 2009 when the program was doubled (Fujian EPB 2009).[6]

Figure 2: Proportion of River Water with Class I–III Quality in the Min River, 1995–2008 (percent)



Source: Fujian EPB (2005).

[4] Enhancing water treatment is not an option once water quality deteriorates below class III since it is the lowest level of water eligible for drinking after treatment.

[5] The Min River was highly polluted before 1997. In 1992 only 30% of its water was classified as class III or above. The Fujian provincial government launched its first Min River Environmental Protection campaign during 1998–2000 targeting industrial pollution from stationary sources. However, the water quality started to degenerate after it reached a peak in 2001, with most of the pollution contributed by nonpoint agricultural sources.

[6] The rest of program funds before 2009 came from the Fujian provincial government (CNY30 million per year) and the Nanping and Sanming governments (CNY5 million per year each). In 2009, the provincial contribution increased to CNY60 million, while Nanping and Sanming's remained the same. Considering that the Min River protection also generated benefits to the province as a whole and the upstream cities, the funding from corresponding sources conceivably internalized these benefits.

While the government initiative was important for starting the process, it generated efficiency and sustainability concerns. While government budgets are financed by public revenues, payment using government budgets is not directly linked to water usage and, hence, to the WTP of individual beneficiaries. To better reflect the values of the environmental service and to be sustainable in the long run, it is recommended that PES programs be transformed from government financing to user financing (Engel, Pagiola, and Wunder 2008). The basic idea of the latter is to raise extra funds through a water tariff increase and earmark the funds for upstream water pollution control.

A key element of the success of a user-financed PES program is determining the appropriate level of water tariff increment, which would depend on the mean WTP of residential water users for clean drinking water. As reviewed below, literature on the WTP for water quality of urban households is sparse. Moreover, WTP may vary with income level and other factors, such as water demand and pollution awareness. It is therefore necessary to obtain city-based WTP estimates. The primary contribution of this paper is to fill in this gap with reliable evidence from Fuzhou City. The results could be used not only to inform relevant policy makers, but also to provide reference information for cities with similar income levels and water resource constraints.

It is recognized that increasing a utility tariff is a politically sensitive issue almost everywhere in the world, and the PRC is no exception. In 2009, debate over proposed water tariff increases in numerous cities of various sizes at different income levels reached new heights.[7] Proponents of water tariff increases, mostly local governments and water companies, argued that current water tariffs are too low to recover the financial costs of water supply and wastewater treatment, let alone the environmental and resource depletion costs of water use. They also noted that other countries' water tariffs are higher and water expenditures account for a larger proportion of urban incomes than in the PRC. Opponents counter that a lack of transparency in utility operations makes it unclear what causes the financial deficiencies of the water supply companies and wastewater treatment facilities. When a utility is privatized, the public grows concerned that this will trigger a water tariff increase due to the initial high selling price of the utility or the undue profit demands of the acquisition companies. Although water tariffs appear lower and less income is spent on water in the PRC, per capita income level is also lower and a larger share of income has to be spent on food and housing than in the comparison countries.

These heated debates convey some important messages, but they do not necessarily foreshadow the rational choice people would make between a reasonable price increase and unsafe drinking water. Nor can they precisely inform policy makers of the prevailing valuation of residential water users for clean water sources. The design of the survey in Fuzhou allows us to investigate who would object to a proposed water tariff increase and what factors drive individuals' decisions, in addition to estimating the mean WTP

[7] The Administrative Regulation on Urban Water Supply Pricing introduced in 1998 assigns the responsibility of setting water tariffs to municipalities (World Bank 2009).

for an upstream reduction in water pollution. Moreover, we analyze affordability and the distributional effects of a water tariff increase, which could shed light on some of the water tariff reforms under consideration.

In the rest of the paper, Section II reviews PES practice in and outside the PRC, in particular cases of watershed protection and water pricing and WTP for water services in the PRC. Section III introduces the survey methodology and the econometric models, and Section IV summarizes the data. Section V reports estimation results. The effects of income level and distribution on WTP, the costs and benefits of the Fuzhou PES program, and the affordability and welfare impacts of water tariff increases are discussed, based on the estimates. Section VI concludes.

II. Literature Review

A. PES in and outside the PRC

The earliest practices of PES in the world are associated with watershed management and potable water supply (World Bank 2009). Landell-Mills and Porras (2002) survey 61 watershed-based payment schemes. They find that markets for watershed services have only recently been established, thus there is still a lack of documentation and assessment of their effectiveness. Usually, markets for watershed services are small-scale and involve a relatively small number of easy-to-identify providers and beneficiaries. In larger watersheds, hydrological links between upstream land use and downstream water impacts are weak and uncertain, so it is more difficult to measure whether and how much beneficiaries may be willing to pay for services. One example involving international trade between Argentina and Bolivia is included in the survey.

One of the best-known examples, which is also highly similar to our Fuzhou case, is New York City's Watershed Agriculture Program (USEPA 2006, Pagiola and Platais 2007). The city obtains its water supply from watersheds in the Catskill Mountains north of the city. In the late 1980s, many dairy and livestock farms emerged in the Catskills, leading to serious nonpoint source pollution, sewage contamination, and soil erosion directly threatening drinking water safety. City water planners launched the Watershed Agriculture Program in 1994 to address the issue. The program included payment by the water utility to the Catskills farmers for both on-farm capital costs and pollution-reducing agricultural measures. The program cost New York City about $1.5 billion to implement, 20% less than constructing and operating a water treatment system.

The PRC government has been experimenting with PES schemes since the 1980s, when the Ministry of Water Resources attempted to protect fragile watersheds through the contracting out of land in sensitive areas to households, conditional upon their adoption of appropriate management practices. As early as 1991, market mechanisms for watershed management were introduced in legislation, in this case the Water and Soil Conservation Act. In recent years, interest in PES as a policy instrument for environmental management and ecosystem protection has kept growing in both central and local governments.

While a PES payment system can take many forms, such as a voluntary contractual agreement, public payment scheme, or trading scheme (Salzman and Lin 2010), the government-led PES, with heavy reliance on public financial transfers, is dominant in the PRC. For example, several PES schemes implemented by the central government are among the largest public payment schemes for ecosystem services in the world. They include the Sloping Land Conversion Program, the Natural Forest Protection Project, and the Forest Ecosystem Compensation Fund. Some regional or local level PES programs, mainly using public funds, include the water rights trading scheme between Yiwu and Dongyang cities in Zhejiang Province; the evolving framework of integrated watershed management and payments being developed between Beijing, Tianjin, and local governments in the upper watershed of the Miyun reservoir; and the water use payment scheme between the water company in Lijiang and Baisha town and the nearby water sources. Unfortunately, the effectiveness and efficiency of some of these programs are being questioned. Recent analysis (IIED 2006, Xu et al. 2006, White and Martin 2002, Scherr et al. 2006, and Uchida et al. 2007) has raised concern over the long-run financial sustainability of some national programs. It has been suggested that the problems with current PES practices lie partly in neglecting the roles of environmental service providers and beneficiaries in the transaction. In a PES driven by private players, the government could play a supporting role in creating and maintaining an enabling market environment (World Bank 2009).

B. Water Tariffs and WTP for Water Services in the PRC

Urban water tariffs for residential use typically consist of two parts: a water supply fee and a wastewater treatment fee. To reflect the environmental value and scarcity of water resources, the water resource fee has been introduced into water tariff structures in recent years in some cities. Domestic water tariffs in the PRC have been increasing constantly since the early 1990s. From 1998 to 2007, water tariffs in 35 major cities rose on average by 7.1% annually. By the end of 2008, the average domestic water tariff in these cities was around CNY2.40 per cubic meter, of which CNY0.67 or so is a wastewater charge.[8] Fuzhou adopts an increasing block tariff structure. The base water tariff is CNY2.05 per cubic meter, including a CNY0.85 wastewater treatment fee. For monthly water consumption between 18 and 25 cubic meters and above 25 cubic meters,

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8 Wangjun Zhou, Vice Director of Price Bureau, National Development and Reform Commission, in an interview with CBN in July 2009.

the water charges are CNY2.65 and CNY3.25, respectively, with the increments attributed to water supply.

But current water tariffs are still considered too low given that utilities' revenues do not fully cover financial costs in many cities (World Bank 2009). Subsidies using public funds are the sector norm. According to the National Development and Reform Committee, the average water treatment charge in the big cities is equivalent to two thirds of the treatment cost. A large number of cities still lack adequate wastewater treatment capacity. Water tariff reform featuring further hikes to water tariffs could send the right signals about the scarcity of water and induce more water conservation and efficiency in water use. Nevertheless, the optimal tariff structure, water users' WTP, and the equality of tariff reform, among others, are issues that need to be investigated carefully. In the case of Fuzhou City, we need to know how much residents are willing to pay to upstream polluters for less discharge and better pollution control, whether the total WTP is adequate to finance upstream efforts in pollution reduction, and how a tariff increase based on the average WTP would affect the welfare of different income groups.

Compared to the large body of literature on WTP for water supply and quality in the developed and some developing countries (e.g., Viscusi et al. 2008, Ojeda et al. 2008), studies on the economic valuation of water services and clean water from the demand side are quite limited in the PRC. The World Bank sponsored a contingent valuation study in Chongqing City, one of the biggest in the western PRC. Wang et al. (2008) analyze the survey data on WTP for better water service among 1,500 households. The survey used a multiple-bounded discrete choice model, which asked respondents to indicate their levels of acceptance with respect to a list of potential water prices.[9] The analyses show that the average WTP is between CNY2.5 to CNY3.3, or 14% to 50% greater than the existing average tariff of CNY2.2. WTP is lower in absolute terms in poorer households, but as a percentage of income it is higher than the existing average. About 20% of households strongly reject a moderate price increase and the rejection rates go up with the proposed water tariff, even though the average economic burden is no higher than 2.1% of income. The authors conclude that water tariff reform that aims at a price increase could be successful if a subsidy is applied to the poor, and public awareness and accountability are raised. To the best of our knowledge, there is no evidence on WTP among the Chinese for protecting water sources through upstream pollution control.

[9] It is noted that the multiple-bounded discrete choice modelapproach has a potential bias problem associated with the order of presenting the water prices to the respondents.

III. Methodology

A. Survey Design

To estimate residents' WTP for water source pollution control, a contingent valuation (CV) survey is designed following the CV practice protocol recommended by the National Oceanic and Atmospheric Administration panel (Arrow et al. 1993). The survey employs in-person instead of telephone-based or web-based interviews, aiming for more precise information and less uncertainty in the responding sample. The questionnaire contains five sections: survey background and purpose; household demographic and socioeconomic profiles; water consumers' perception of water quality; and WTP elicitation and debriefing. The interview begins with an introduction in which the following scenario is described: the majority of residential piped water comes from the Min River, whereas public funds for pollution treatment fall short because pollution sources are numerous and widespread in the broad upstream area. If additional revenues could be generated from a tariff increase for piped water, upstream farmers would be paid for pollution control, and downstream water users would benefit. The hypothetical commodity for which interviewed households are asked to pay is described as the avoidance of a deterioration of Min River water to below class III of GB3838-2002 from the present class III.

The WTP is elicited through two sequential questions in a referendum format. First, the respondent is asked whether he/she is willing to see an increase in the water tariff if extra funding needs to be raised through an increase in the water bill to treat Min River pollution, in particular to treat the nonpoint pollution from the upstream livestock industry. Those answering "no" are asked to choose from a list of reasons or give their own reasons. Those answering "yes" are then asked whether they are willing to pay a specific increase on top of the current tariff. The bid of the increase for each interview was randomly selected from five possibilities, i.e., 0.1, 0.3, 0.6, 0.9, and 1.2 (CNY/cubic meter). These bids range from 8% to 100% of the existing base water supply fee (excluding CNY0.85 /cubic meter of wastewater treatment fee) and from 5% to 59% of the base total water tariff. The survey reminds respondents to take into account the implied increase in expenditure, proportion of the water bill increase in total monthly expenditure, and potential alternative uses of the money. Once asked, the interviewer informs the respondent of the existing water tariff divided into base water fee and wastewater treatment fee. To confirm the answer, after the respondent answers yes or no, an open-ended question follows asking for brief reasons for approving or not approving the proposed increase.

B. Survey Administration

A total of 14 enumerators (eight female and six male undergraduates from local universities or graduates from China Agricultural University in Beijing) were trained to conduct interviews. The training aimed to have the enumerators understand the purpose of the survey, become familiar with the survey instrument, and acquire and share survey techniques. The questionnaire was also refined during the training. The following activities were included in the training:

(i) discussion of the purpose of the survey

(ii) explanation of the CV method and enumerator rules recommended in ADB (2007)

(iii) discussion of the questions in the questionnaire

(iv) specific discussion of the WTP elicitation question and how to ask it

(v) discussion of how the survey data would be used in the final analysis

(vi) role-playing where some enumerators act as interviewees

The draft questionnaire was pretested with 20 respondents, revealing some deficiencies and leading to important changes, including, among others: shortening the opening introduction from 5 to 2 minutes; asking about incomes in brackets rather than exact numbers; clarifying that housing area refers to construction area;[10] obtaining the respondent's precise address from the enumerators rather than from the respondents; and using the local dialect in interviewing elderly respondents.

The 14 enumerators were divided into four teams, each with a coordinator whose responsibilities included onsite supervision of interviews and revisiting selected samples. During onsite supervision, the coordinator ensured the completion of interviews, answered unusual questions encountered by team members, and reviewed the completed questionnaires before leaving the site.

The survey was targeted at four urban districts of Fuzhou City that draw their drinking water from the Min River—Gulou, Taijiang, Cangshan, and Jinan—excluding the Mawei district, which obtained its water from an alternative source. Since little evidence was found suggesting significant differences across districts, a neighborhood-level stratification sampling frame was adopted. By the end of 2008, there were a total of 292 neighborhoods hosting 543,133 households in these four districts (Fuzhou Statistical Bureau 2009). Although efforts were made to access all neighborhoods, some were very difficult to reach and thus were missing in the sample. The survey, in the end, covered 256 neighborhoods for a coverage rate of 87.7%.

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[10] Construction area of an apartment differs from the actual living area in terms of including the share of public area such as stairs and elevators. It is generally 20–40% bigger than the actual living area in the PRC.

Given budget and time constraints, the planned sample size was 750. Interviewers conducted the survey on 7–14 July 2009 and collected 777 responses, accounting for about 1.43% of the population. The coordinators conducted random revisits to 37 households, about 5% of the sample, either by telephone interview or in person. Two interviews done in a park near the neighborhood, which could not be verified, were removed from the sample, leaving 775 valid observations.

C. Econometric Models

The primary question this study attempts to answer is how much an average household would be willing to pay to control water source pollution through a PES system. The sequential structure used to elicit WTP yields three categories of households. The first is those unwilling to pay a water tariff increase at all, putting their WTP theoretically at or below zero.[11] The second is willing to pay a surcharge less than the tariff increase proposed to them in the survey, putting their WTP between a range bounded by zero and the price increase bid. The third approves of the proposed specific tariff increase, implying a WTP above the bid. Following Hanemann, Loomis, and Kanninen (1991), an interval regression model can capture the joint probability of the sample households revealing themselves into respective categories, and thus estimate the mean or median WTP for upstream pollution control delivered by a PES system, as well as the impacts of individual and household characteristics on the WTP.

Assume y_i^* is the latent WTP of individual i for water quality improvement, which we do not observe directly. What we observe is the WTP interval that y_i^* falls into. The two-step WTP elicitation process can be formulated as follows: in the first step, individuals would reveal their WTPs between intervals $(-\infty,0]$ and $(0,\infty)$; in the second step, those whose WTPs fell in $(0,\infty)$ were asked to further reveal their WTPs into interval $(0,\alpha_i)$ or $[\alpha_i,\infty)$, where α_i is the random bid of water tariff increase presented to individual i. Thus, y_i^* is narrowed down to one of the three mutually exclusive intervals, i.e., $(-\infty,0]$, $(0,\alpha_i)$, $[\alpha_i,\infty)$ denoted by 1, 2, and 3 respectively. Let d_{ij}, $j=1,2,3$, be indicator equal to 1 if y_i^* falls into interval j and 0 otherwise. The probability of observing i's responses is

$$\mathrm{P}_i = \Pr(y_i^* \le 0)^{d_{i1}} \cdot \Pr(0 < y_i^* < \alpha_i)^{d_{i2}} \cdot \Pr(y_i^* \ge \alpha_i)^{d_{i3}}.$$

Modeling the latent WTP as a sum of deterministic and stochastic elements: $y_i^* = X_i\beta + \varepsilon_i^*$, where the deterministic element is a linear combination of household characteristics, X_i, and $\varepsilon_i^* \xrightarrow{i.i.d} F^*$. Then the probability becomes

$$\mathrm{P}_i = F^*(-X_i\beta)^{d_{i1}} \cdot [F^*(\alpha_i - X_i\beta) - F^*(-X_i\beta)]^{d_{i2}} \cdot [1 - F^*(\alpha_i - X_i\beta)]^{d_{i3}}.$$

[11] The negative WTP is possible here as the respondents may think that they deserve better quality of water for paying at the current water tariff; or, the water tariff should be lowered if the water quality cannot be improved.

The log-likelihood function for the joint distribution, which is to be maximized by MLE, is

$$\ln L(\beta) = \sum_i d_{i1} \ln F^*(-X_i\beta) + d_{i2} \ln[F^*(\alpha_i - X_i\beta) - F^*(-X_i\beta)] + d_{i3} \ln[1 - F^*(\alpha_i - X_i\beta)]$$

IV. Data

Among the 775 valid households, those with respondents below age 17, missing important explanatory variables (e.g., income), or having inconsistent responses were dropped from the sample. The final sample consisted of 757 households. The dropped observations had little influence on the descriptive and regression results.

Table 1 reports means and standard deviations of respondent characteristics for the whole sample and approval or nonapproval of a water tariff increase. The average age of respondents was 47. Among the respondents, 40% were male, 39% had a high school diploma, and 20% a college or higher degree. An average household had 3.7 permanent residents living in an area of 94 square meters. Monthly water consumption was 16 cubic meters. Monthly disposable incomes was between CNY1,000 and 6,000 (about US$147–882, respectively. When asked about perceived water quality, 11% of the respondents said piped water was not good, and 34% ranked the water quality of the Min River as not so good or bad.

Regarding water tariff increases, 326 respondents, or 43% of the sample, said they would not approve. Among them, 123 said the government should be responsible for pollution mitigation; 22 attributed the responsibility of cleaning water to water companies; and 31 attributed the responsibility to upstream polluters. High water tariffs or low income was another major reason for rejecting the proposal. Among respondents, 194 said that either the water tariff was already high or an additional water charge would be a burden. A considerable portion of respondents (44) were concerned with the effectiveness of the tariff increase on pollution mitigation. They doubted that the money would be used for reducing upstream pollution. Examining individual and household characteristics between households agreeing and disagreeing with a water tariff increase, we found that significant differences exist in age, gender, and education of the respondents, as well as in household income and living space. People who agreed with the idea of a water tariff increase were on average younger, more likely to be male, better educated, and come from wealthier families with a more spacious residence than those who disagreed. More respondents who would accept the water tariff increase had an impression of bad water quality for the Min River but not for piped water. While this comparison is informative, some characteristics such as household residence and income are highly correlated. We present the regression results below to see how each characteristic affects the attitude toward a water tariff increase when other characteristics are controlled for.

Table 1: Summary Statistics of the Overall Sample and Approval or Nonapproval of a Water Tariff Increase

Variables	Definition	Whole Sample		No Increase		Increase	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Age	Age	46.89	16.59	48.86	16.00	45.39	16.89
Male	Male	0.400	0.490	0.387	0.488	0.411	0.493
Lowedu	Below high school education	0.410	0.492	0.482	0.500	0.355	0.479
Hsch	High school and college associate	0.390	0.488	0.377	0.485	0.399	0.490
College	College or higher degree	0.201	0.401	0.141	0.349	0.246	0.431
Hhsize	Number of permanent residents	3.697	2.018	3.856	2.249	3.578	1.817
Livingsp	Housing construction area (square meters)	93.90	47.07	91.98	48.58	95.35	45.90
Waterdmd	Monthly water consumption (cubic meters)	15.88	12.28	15.74	11.66	15.99	12.74
income1	Monthly income below 1000 CNY	0.054	0.226	0.083	0.276	0.032	0.177
income2	Monthly income 1000-2000 CNY	0.221	0.415	0.252	0.435	0.197	0.398
income3	Monthly income 2000-4000 CNY	0.345	0.476	0.365	0.482	0.329	0.471
income4	Monthly income 4000-6000 CNY	0.196	0.397	0.160	0.367	0.223	0.417
income5	Monthly income 6000-8000 CNY	0.078	0.268	0.074	0.262	0.081	0.273
income6	Monthly income 8000-10000 CNY	0.059	0.237	0.037	0.189	0.077	0.266
income7	Monthly income above 10000 CNY	0.048	0.213	0.031	0.173	0.060	0.238
Waterbad	Piped water is bad	0.106	0.308	0.104	0.306	0.107	0.309
Riverbad	Min River water is bad or not so good	0.342	0.475	0.310	0.463	0.367	0.482
Obs	Number of observations	757		326		431	

Std. dev. = standard deviation.
Source: Authors' estimation using Fuzhou household WTP survey data.

One objective of our analysis was to infer citywide residential WTP for upstream water source pollution control through PES. Therefore, it is critical to have a sample representative of the population of city residents. Table 2 compares several key variables of the sample with those in the *Fuzhou Statistical Yearbook 2009* (Fuzhou Statistical Bureau 2009), the best source we found for information on the city population. Note, however, that the comparison is not ideal in that the *Fuzhou Statistical Yearbook 2009* provides statistics for 2008 for the whole city, including Mawei district, while our July 2009 sample excluded Mawei. In addition, statistics computed for the sample could also differ in definition from those in the yearbook.

Rows 1 and 2 of Table 2 show that the average sample household is nearly 20% bigger than that in the yearbook and has a 40% larger per capita housing area. The differences are statistically significant and unlikely to be explained by the time gap between the sample and the yearbook because family size in the city was quite stable in the past decade. The survey asked about apartment construction area, which is generally 20–40% bigger than the actual living area in the PRC. The gap could be reconciled in cases where the yearbook reports living area. Nevertheless, a sampling error due to oversampling of large households might be the primary cause. Although households in the sample appear to have more living space, income data do not suggest that they are wealthier than the population on average. To get a point estimate of mean household income, we assign the midpoint and the upper bound of the income bracket chosen by the respondent as household income. Sample mean income based on the midpoint is accurate if respondents report their incomes precisely and the income distribution is symmetric around the midpoint within each bracket. However, considering the multiple income sources of some households and the conservative tendency among Chinese about revealing their incomes, applying the upper-bound value of each bracket to calculate the sample mean may provide a more reliable estimate. The sample mean income based on midpoint is CNY14,839 per capita per year, which is CNY4,300 or 20% less than the mean in the yearbook and which is statistically significant. The mean income gets very close and statistically indifferent to the yearbook average when calculated using the bracket's upper-bound value. The difference diminishes to only CNY500, or 3% less than the average reported in the yearbook. Since household income rather than number of residents or housing area is the most important determinant of WTP and affects WTP positively, as shown in the following regressions, our estimates are likely to capture the WTP of the population. Finally, water consumption is strikingly consistent between the sample and population. An average sample household spends CNY10.25 per capita every month on piped water while the figure in the yearbook is CNY10.5. This result, together with the income data, raises a fair degree of confidence in the data set and the estimation results.

Table 2: Representativeness of the Sample

	Sample Mean	Yearbook[a]	t-test (p-value)[b]
Household size (person)	3.70	3.10	8.148 (<0.001)
Housing area (square meters/person)	28.72	20.50	13.68 (<0.001)
Annual income, using mid-point (CNY/person)	14,839	19,140	−9.118 (<0.001)
Annual income, using upper bound (CNY/person)	18,631	19,140	−0.971 (0.332)
Water bill (CNY/person/month)	10.25	10.50	−0.923 (0.356)

[a]*Fuzhou Statistical Yearbook 2009* (Fuzhou Statistical Bureau 2009).
[b]The null hypothesis is: sample mean = value in the *Fuzhou Statistical Yearbook 2009*.

To further pin down the WTP of those amenable to the water tariff increase proposal, a specific price increase was suggested to them. It was important to have the bids randomly distributed across respondents to obtain unbiased estimation of the models. We conducted an *F*-test to check the balance of bids distribution among various individual and household characteristics. As shown in the last row of Table 3, the numbers of respondents receiving different price increase bids are nearly equal. The *F*-tests demonstrate that the bids are well balanced for all the characteristics except for gender and perception of the Min River's cleanliness, suggesting overall randomness of bids distribution.

The internal validity of the contingent valuation survey requires that the proportion of respondents who accept the proposed price increase declines with the bid. The second to the last row in Table 3 presents a test of this condition. The proportions decrease monotonically from 96.5% with bid CNY0.1 to 82.1% with bid CNY0.3, and so on. When the proposed price increase doubles the base water supply fee and equals 60% of the prevalent total water tariff, only 36% of the respondents would approve the increase. Given that 43% of the entire sample objected to raising the water tariff, these results suggest that about 55% of the households would accept a CNY0.1 increase and 20% would accept a CNY1.2 increase. The *F*-test indicates that the decline is statistically significant and the survey passes the simple scope test. It is also interesting to note that the reasons for approving or disapproving the price increase are quite homogenous. Most people who favor the increase generally expect health and environmental benefits from water quality improvement. The main reason for rejecting the bid is that the proposed price increase is too large. Some respondents said they would accept a price increase in the range of CNY0.1 to CNY0.5. This outcome is encouraging in that it suggests that the respondents took budget constraints seriously in answering the survey questions.

Table 3: Balancing Test on the Randomization of the Bids in the Second WTP Question

Variables	Bid = 0.1		Bid = 0.3		Bid = 0.6		Bid = 0.9		Bid = 1.2		*F*	p-value
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.		
age	44.942	16.808	44.071	17.014	44.953	16.714	46.540	17.677	46.360	16.462	0.33	0.858
male	0.279	0.451	0.548	0.501	0.435	0.499	0.299	0.460	0.494	0.503	5.17	0.0004
lowedu	0.384	0.489	0.310	0.465	0.376	0.487	0.391	0.491	0.315	0.467	0.59	0.673
hsch	0.349	0.479	0.452	0.501	0.318	0.468	0.425	0.497	0.449	0.500	1.36	0.246
college	0.267	0.445	0.238	0.428	0.306	0.464	0.184	0.390	0.236	0.427	0.93	0.445
hhsize	3.721	1.395	3.452	1.383	3.259	1.347	3.931	2.897	3.517	1.501	1.75	0.139
livingsp	99.221	48.459	99.512	45.578	91.509	36.238	91.862	46.598	94.764	51.311	0.60	0.662
waterdmd	16.107	11.100	17.06	11.322	14.466	9.473	17.672	18.81	14.663	10.686	1.07	0.369
income1	0.035	0.185	0.036	0.187	0.059	0.237	0.023	0.151	0.011	0.106	0.86	0.489
income2	0.186	0.391	0.202	0.404	0.176	0.383	0.276	0.450	0.146	0.355	1.30	0.271
income3	0.314	0.467	0.345	0.478	0.388	0.490	0.299	0.460	0.303	0.462	0.54	0.709
income4	0.209	0.409	0.202	0.404	0.176	0.383	0.207	0.407	0.315	0.467	1.45	0.215
income5	0.081	0.275	0.107	0.311	0.047	0.213	0.080	0.274	0.090	0.288	0.54	0.706
income6	0.105	0.308	0.048	0.214	0.082	0.277	0.080	0.274	0.067	0.252	0.53	0.717
income7	0.070	0.256	0.060	0.238	0.071	0.258	0.034	0.184	0.067	0.252	0.35	0.846
waterbad	0.140	0.349	0.083	0.278	0.094	0.294	0.092	0.291	0.124	0.331	0.51	0.727
riverbad	0.372	0.486	0.429	0.498	0.247	0.434	0.345	0.478	0.438	0.499	2.21	0.067
approval	0.965	0.185	0.821	0.385	0.647	0.481	0.448	0.500	0.360	0.483	30.64	0.000
obs	86		84		85		87		89			

Std. dev. = standard deviation

Source: Authors' estimation using Fuzhou household WTP survey data.

V. Results

This section reports estimation results related to WTP for upstream water source pollution control through PES. First, we examine what explains one's position with respect to the water tariff increase proposal (response to the first WTP question). Second, we look at what roles the tariff increase bid as well as other characteristics play among those who favor the increase in accepting a specific amount of tariff increase (response to the second WTP question). The two questions are modeled with separate Logit models. With the sequential structure of WTP elicitation, however, people who answered both questions and those who answered "no" on the first question and therefore did not proceed to the second are not two independent subsamples. To estimate WTP for the entire sample, we need a model that integrates both groups and employs all the information available from the two WTP questions. In the third step, we use an interval regression model, as described in the previous section, to achieve this goal.

A. Separate Logit Models

Column (1) of Table 4 represents a simple Logit model with the dependent variable being whether one approves of a water tariff increase in general. While the summary statistics show that significant differences in individual characteristics such as age, gender, education, and perception of the Min River quality exist between people holding opposite opinions, the differences are gone in the multivariate analysis. The most important factor that affects people's position is household income. According to the regression estimates, the probability of approving the water tariff increase rises by 17 percentage points when one household's income increases from the lowest bracket of CNY1,000 or below (the omitted group) to the bracket between CNY1,000 and CNY2,000.[12] The approval probability for households in the top two income brackets (monthly income greater than CNY8,000) is 30 percentage points higher than that for households in the bottom bracket. It is also noted that the effects of higher income on the acceptance of water tariff increases is not smooth. The share of positive responses shoots up for households with income above CNY4,000 and for those with income above CNY8,000. Other household characteristics, except household size, are not important in the model. Household size has a small, negative impact on respondent's choice, which probably reflects the income effect in per capita terms.

[12] The predicted probability for households in the lowest bracket is 35%.

Table 4: Models of WTP for Water Source Pollution Control

	(1)	(2)	(3)	(4)
age	−0.001	−0.009***	−0.009***	−0.009***
	(0.001)	(0.002)	(0.002)	(0.003)
male	0.007	0.155***	0.142***	0.120
	(0.039)	(0.052)	(0.053)	(0.103)
hsch	0.019	0.043	0.044	0.062
	(0.046)	(0.0614)	(0.065)	(0.121)
college	0.089	−0.042	−0.036	0.176
	(0.062)	(0.086)	(0.088)	(0.165)
hhsize	−0.026*	−0.008	−0.005	−0.063
	(0.015)	(0.025)	(0.025)	(0.043)
livingsp	−0.0002	0.0006	0.0006	−0.001
	(0.0005)	(0.0007)	(0.0007)	(0.001)
waterdmd	0.001	−0.006**	−0.006**	−0.0001
	(0.002)	(0.003)	(0.003)	(0.005)
income2	0.172**	0.052	0.056	0.496**
	(0.0799)	(0.143)	(0.144)	(0.239)
income3	0.194**	−0.023	−0.024	0.515**
	(0.082)	(0.160)	(0.161)	(0.238)
income4	0.263***	0.106	0.107	0.825***
	(0.076)	(0.137)	(0.140)	(0.262)
income5	0.210**	0.189**	0.196**	0.776**
	(0.086)	(0.090)	(0.093)	(0.312)
income6	0.295***	0.189**	0.202**	1.151***
	(0.072)	(0.087)	(0.087)	(0.337)
income7	0.291***	0.089	0.084	1.015***
	(0.072)	(0.144)	(0.153)	(0.336)
waterbad	−0.005	0.054	0.062	0.027
	(0.059)	(0.072)	(0.073)	(0.153)
riverbad	0.0514	−0.106*	−0.119**	0.043
	(0.040)	(0.054)	(0.057)	(0.100)
Bid=CNY 0.3		−0.503***		
		(0.130)		
Bid=CNY 0.6		−0.677***		
		(0.093)		
Bid=CNY 0.9		−0.769***		
		(0.065)		
Bid=CNY 1.2		−0.830***		
		(0.048)		
Bid			−1.386***	
			(0.279)	
Bid square			0.515**	
			(0.201)	
Observations	757	431	431	757
pseudo R2	0.037	0.325	0.318	-

*** indicates statistical significance at 1% level.
** indicates significance at 5% level.
* indicates significance at 10% level.
Note: Marginal effects for the Logit models in (1)-(3). Robust standard errors reported in parentheses.

Columns (2) and (3) present results from Logit models that take the subsample of respondents who approve of a water tariff increase and examine their responses to the specific bid of the tariff increase. In the first model (Column (2)), a set of dummies is used for the bids, with the lowest bid of CNY0.1 omitted. The second model includes quadratic terms of bids. Results indicate that WTP for water source pollution control declines with the additional payment required to cover the cost. Holding other variables constant at sample means, the probability of respondents approving a CNY0.3 increase in water tariff is 50 percentage points lower than that of a CNY0.1 increase, even though they all agree to pay something to control pollution. The decline is monotonic and slow with a higher bid (positive coefficient for the second-order term in column (3)). Both models confirm that the survey generates data that pass the test of internal validity conditional on other observables. However, these estimates should not be treated as those from a singlebounded CV sample because the subsample on which the estimates are obtained is screened by the first WTP question. An alternative model resolving the issue will be presented next. Variables such as age, gender, water consumption, income, and perception of river water quality also affect one's response. For instance, households consuming more piped water are less likely to accept the same amount of tariff increase than households consuming less water, everything else remaining the same. Again the information should be taken with caution as they do not represent the impacts on the WTP for the whole sample.

B. Interval Regression for WTP

Column (4) in Table 4 reports estimates of an interval regression model for the WTP of the survey sample. For individuals who opposed increasing the water tariff, the WTP is assumed to be less or equal to zero; for those rejecting the proposed tariff increase, the model assumes the WTP between zero and the bid; and for those favoring the increase the WTP should be equal or greater than the bid. Thus, the interval model is able to fully utilize the information available from the sequential WTP questions, and yield unbiased, efficient estimates for the entire sample.

The pattern of column (4) is highly similar to that of column (1): income is the most important factor, in both economic and statistical terms, that determines one's WTP for upstream pollution control. This result is consistent with the findings in Chongqing (Wang et al. 2008). On average, households with monthly incomes between CNY1,000 and CNY4,000 are willing to pay CNY0.50 more per cubic meter of piped water than households earning less than CNY1,000. Households with incomes between CNY4,000 and CNY8,000 and above are willing to pay CNY0.80 and CNY1.10 more, respectively, than the lowest income households. Moreover, the effects of income on the WTP appear to be discontinuous. About four income groups can be identified: those with monthly income below CNY1,000; between CNY1,000 and CNY4,000; between CNY4,000 and CNY8,000; and above CNY8,000. Households share similar valuations of water quality improvement within each group and have distinct valuations across groups. The strong role household income plays in forming WTP presents at least two policy implications. First, a city's aggregate WTP for upstream water source pollution control could be highly correlated with the city's income level and perhaps income distribution, too. Second, a welfare-enhancing policy to increase residential water tariff must take into account households' unequal income levels and better be accompanied by a reasonable subsidy or transfer plan. We elaborate on these two implications below.

Table 5 presents the predicted WTP mean for the whole sample as well as for different income groups. For an average household—all characteristics valued at sample means—the mean WTP for water source pollution control through PES is estimated to be CNY0.21, equivalent to a 10% increase from the current water tariff, or CNY2.05 per cubic meter. The 95% confidence interval for the mean WTP is (0.117, 0.306). The total annual WTP can be obtained for the whole city by extrapolating the estimated mean WTP of the population. Given a total of 543,133 households in the four districts of Fuzhou, whose drinking water comes from the Min River and whose water consumption per month per household is 15.88 cubic meter, the total annual WTP of the four districts amounts to CNY21.8 million.[13] The confidence interval ranges from CNY12.1 million to CNY31.7 million per year.

Table 5: Predicted Mean WTP and Total WTP for the Population and by Income

Group	Mean WTP (CNY)	95% Confidence Interval (CNY)	Sample Share	Monthly Water Consumption per Household (cubic meters)	Total Annual Water Consumption (million cubic meters)[a]	Total Annual WTP (CNY mil.)
All	0.211	(0.117, 0.306)	1.000	15.88	103.49	21.84
income1	–0.45	(–0.879, -0.021)	0.054	10.24	3.60	–1.62
income2	0.007	(–0.194, 0.208)	0.221	15.38	22.15	0.16
income3	0.083	(–0.069, 0.236)	0.345	14.45	32.50	2.70
income4	0.449	(0.238, 0.661)	0.196	17.74	22.67	10.18
income5	0.411	(0.041, 0.782)	0.078	18.02	9.16	3.76
income6	0.856	(0.417, 1.296)	0.059	21.04	8.09	6.93
income7	0.731	(0.288, 1.174)	0.048	17.33	5.42	3.96

[a] Annual total water consumption is the product of monthly water consumption per household; total number of households (543,133); sample share; and number of months per year.

Note: The predictions are based on the model estimated in column (4) of Table 4. Individual and household characteristics other than income are valued at sample means or subsample means for each income group.

Table 5 shows that the mean WTP varies considerably with income level.[14] For the lowest income group, the predicted mean WTP is negative and statistically different from zero.

[13] As a life essential, the own price elasticity of drinking water is small. Zhang et al. (2007) estimate the price elasticity of residential water demand across different income groups in Beijing and find that it falls between –0.6 to –0.8, except for households in the top 20%. Applying these figures, our calculation assuming zero price elasticity overstates the total WTPs by 6–8%. Also note that column (4) in Table 4 shows that respondents did not give much weight on actual water consumption in answering the WTP questions.

[14] The mean WTP for each income group is calculated with other characteristics valued at the means of the group subsample.

The mean WTPs for income groups between CNY1,000 and CNY4,000 are CNY0.01 and 0.08, respectively. They are smaller than the mean WTP of the sample and are not statistically distinguishable from zero. Noticeably, households within this income range account for more than 50% of the population. WTPs increase substantially for those with monthly income exceeding CNY4,000. For households earning CNY4,000–8,000, the mean WTP is equal to about CNY0.45. For incomes greater than CNY8,000, the mean WTP jumps to around CNY0.80.

In light of the great influence income has on WTP for water pollution control, we conduct two simple numerical experiments to explore how the mean WTP is associated with income level and distribution. Because we only know which income bracket each household belongs to, it is difficult for us to shift the actual income of each household or to change the income distribution while holding average income level constant *per se*. In the first exercise, we look at a scenario where each household moves up the income bracket above its current bracket except for the top bracket. As a result, 5.4% of households now earn CNY1,000–Y2,000 per month; 22.1% of households earn CNY2,000–4,000, and so on. This approximates a 43% increase (CNY26,723 vs. CNY18,631) in annual average per capita income when the upper bound of each bracket is assigned to the households in the bracket. Holding other characteristics fixed, the simulation suggests that the predicted mean WTP would increase to CNY0.36 with the confidence interval of (0.23, 0.49). The mean WTP increases by CNY0.15 or 70% as compared to the WTP for the current income, which implies an income elasticity of WTP greater than one. The total WTP should go up more because water consumption has a positive income elasticity.

The second exercise is concerned with the effect of income distribution on the mean WTP. First, if the lowest income bracket households were all to move up to the next income bracket, i.e., CNY1,000–2,000, the mean WTP would increase to CNY0.24. Note, however, that the income gap is reduced due to poverty reduction (income level change) in this case. Second, we consider a scenario where income inequality is enlarged. Suppose that 5% of households in bracket CNY4,000–6,000 were moved down to the brackets below CNY1,000 (2.5%) and between CNY1,000–2,000 (2.5%). Another 5% of households from the bracket CNY4,000–6,000 were moved up to the bracket CNY8,000–10,000. By symmetry, the average income level is roughly unchanged. Our model suggests that the mean WTP would change little in this scenario, which is more or less expected since the high-income households' higher WTP would offset low-income households' lower WTP. The simulation, though illustrative rather than conclusive, suggests that a city's mean WTP for water pollution control is affected more by income level than by income distribution.

C. Cost–Benefit Analysis for the Fuzhou PES Program[15]

It is estimated that the total investment needed for Nanping livestock farms pollution control is CNY410–464 million for fixed costs and CNY27 million for annual operations and maintenance costs (ADB 2009). This includes installing and operating waste treatment facilities for 544 large and medium livestock farms and setting up household-based biogas systems involving 480,000 small farms. Cost information for Sanming City is missing and we assume the same amount of fixed costs and operations and maintenance costs. The net present value of the costs of the Min River upstream pollution control, with 6% discount rate and project lifecycle of 25 years, is around CNY1.5 billion.

Suppose that the 2009 PES financing frame is maintained for the provincial government and upstream governments, which pay a total of CNY70 million to the program every year. Nevertheless, Fuzhou City pays CNY22 million, which is equal to the total WTP financed by additional water utility revenue, instead of the current CNY30 million from the city's budget. Further assume that the total WTP grows 8% annually, which is reasonable and conservative given the prospective income growth leading to higher average WTP and water consumption growth. The PES scheme will be economically viable with net present value ranging from CNY35 million to CNY137 million.[16]

D. Affordability and Distributional Issues

Affordability of water bills, especially to low-income residents, is an issue policymakers have to take into account in water tariff reform. We measure affordability with percentage share of income spent on domestic water. Because the actual income figures are missing, we imputed with the middle-point income as the income level for households in each bracket. The second column of Table 6 shows the results of dividing average household monthly water bills by the imputed incomes. Water expenditure is almost negligible for households earning CNY4,000 or more and accounts for 1–2% of income for those within the CNY1,000–4,000 income bracket. However, for the poorest households, 4.5% of income needs to be spent on water. With a flat-rate increase in water tariff, the poor would be affected more in terms of affordability. The income share for water would reach 5% for the poorest if water tariff were raised by CNY0.21 (third column), while the shares remain below 1% for those earning more than CNY4,000 per month.

In view of the fact that the lowest three income groups accounting for 60% of the population have mean WTP less than the sample average, any reform to increase the

[15] The following calculation is illustrative as a number of assumptions and simplification are adopted. Not taken into calculation are the potential development benefits foregone by the upstream cities, investment already made in pollution management, and actual benefits other than safe drinking water for Fuzhou. These factors and choice of parameters will affect the results in both ways.

[16] The PES will be sustainable even if the overall scale of the program downsizes by 15% to CNY 85 million per year, which means that the payments made by the provincial government and upstream government could downsize by 10% or CNY7 million in addition to CNY8 million reduction in Fuzhou's contribution.

water tariff by the average WTP needs to be combined with some public transfer in order that people are not made worse off. A water bill subsidy based on household income equal to the difference between the price increase and mean WTP (zero if mean WTP is negative) could achieve this goal. That means a subsidy of CNY0.21, CNY0.20, and CNY0.13 per cubic meter of water consumption for incomes below CNY1,000; CNY1,000–2,000; and CNY2,000–4,000, respectively. The last column of Table 6 shows the amount of subsidy needed for each of the three groups every year, which are CNY0.76, CNY4.52, and CNY4.16 million, respectively. A total amount of about CNY10 million is sufficient to ensure that lower-income households are not made worse off by the water tariff increase of CNY0.21 per cubic meter. The negative figures for other income groups represent the consumer surplus left from the reform. The government may exploit this part of benefits to make the reform self-financing. A simple computation indicates that when the water tariff is raised by CNY0.27, the government could have sufficient revenue to compensate for the welfare loss of the lower income households in addition to the total WTP calculated at the mean WTP.

Table 6: Affordability of Water Tariff Increase by Income Groups and Public Transfer Needed

Group	Imputed Monthly Income (CNY)[a]	Average Share of Income for Water Expenses under Current Tariff (%)	Average Share of Income (CNY 0.21) for Water Expenses with Tariff Increase (%)	Difference between Tariff Increase (CNY 0.21) and WTP (CNY)[b]	Public Transfer (million CNY)
income1	500	4.5	5.0	0.211	0.761
income2	1500	2.3	2.5	0.204	4.519
income3	3000	1.1	1.2	0.128	4.160
income4	5000	0.8	0.9	−0.238	−5.394
income5	7000	0.6	0.7	−0.200	−1.832
income6	9000	0.5	0.6	−0.645	−5.219
income7	15000	0.2	0.2	−0.520	−2.820

[a]The middle-point income of each bracket is used as the imputed income value.
[b]For income1 group (below CNY 1,000), the difference is calculated as 0.211 and zero.

VI. Conclusion

Through a contingent valuation survey involving more than 770 households in four districts of Fuzhou City, we estimate the mean WTP of Fuzhou residents for water pollution control administered by upstream cities to prevent the water quality of the Min River from falling below class III. The survey elicited WTP with two sequential dichotomous questions. The first asked respondents about their willingness to have a water tariff increase, and the second asked those who would accept a general water tariff to respond to a specified tariff increase proposal. Data show that 43% of the sample would not approve of a water tariff increase, with economic burden the primary reason, while a significant proportion were concerned about government or the water utility's responsibility in providing clean water as well as the effectiveness of public revenue utilization. Regression results indicate that household income is the most important factor in determining a respondent's position on a water tariff increase. Households with monthly income of CNY1,000–8,000 (accounting for 85% of the population) are 17–26% more likely to approve of a water tariff increase than households earning CNY1,000 or less. Both summary statistics and a Logit model on respondents answering the second WTP question demonstrate that the survey is internally valid in that the probability of approving the specific price increase bid declines with the bid value.

We use an interval regression model to estimate WTP for upstream pollution control. Again, income plays a key role in determining a household's WTP. Households with monthly income below CNY1,000 have negative mean WTP, while households earning CNY1,000–4,000 (60% of the population) are willing to pay around CNY0.50 more than households with income below CNY1,000. The mean WTP for the whole sample is estimated to be CNY0.21, higher than the mean WTP of households earning less than CNY4,000, and lower than that of households earning more than CNY4,000. Simple simulations show that the mean WTP is mainly influenced by income levels with an income elasticity greater than 1. Based on the mean WTP estimate, the total annual WTP of Fuzhou City for upstream pollution control is approximately CNY22 million. Maintaining investments from provincial government and other sources and assuming a 25-year project lifecycle with 6% discount rate, an annual payment equal to the total WTP—CNY8 million less than Fuzhou City's current contribution—is sufficient to sustain the ongoing PES. The finding suggests that the scale of the Min River basin PES can be reexamined with investment needs for upstream pollution control verified. Changing the funding source to water utility revenues from the government budget could improve the program's economic efficiency.

While water tariff reform with continuous water tariff increases is seen as essential for the PRC, our analysis points to the importance of considering the impacts of a tariff increase on different income groups in the reform. In Fuzhou's case, water expenditure is a burden for the lowest income groups, and the mean WTP of households earning less than CNY4,000 per month is below the average WTP of the whole population. A 10% water tariff increase based on the population's WTP will push the bottom households' burden up by about half a percentage point, and result in welfare loss for more than 60% of households.[17] A water bill rebate given to eligible households based on their incomes is desirable so as not to make the water tariff increase hurt low-income families. An alternative approach, more commonly seen in reality, is a combination of moderate increase in base water tariff, enlarged tariff differences in block pricing, and lump-

17 Some argue that low water pricing and associated poor water quality impact the poor disproportionately (e.g., World Bank 2009). First, higher-income households consume more water and therefore benefit more from the subsidies on water. Second, in the presence of poor water quality, expensive substitutes such as bottled water leave poor households no choice but to consume water of inferior quality.

sum subsidies for the poorest households (such as those with monthly income below CNY1,000).

Although PES is increasingly practised as an effective mechanism in dealing with the externality of environmental and ecosystem services, a few issues related to PES are still open for research and policy discussion. PES will be efficient when the transaction cost is relatively low compared to the service benefits. Many institutional factors, not just the numbers of service buyers and providers, affect transaction cost. Thus, the design of a PES scheme has to be tailored to local systems, including the capacity to minimize transaction costs. Moreover, even if the PES is voluntary and user-financed, governments will still play a critical role in designing the program, monitoring service delivery, and enforcing the contract.

Our estimates of mean WTP could be used as a reference point for other PRC cities with similar size and income level. One caveat, however, is that the PES scheme is clearly specified in the survey. Payment for upstream farmers reducing their pollution should be the rationale underlying the responses to the WTP questions. Therefore, our results may be more applicable to some cities than others that motivate water tariff reform differently (Bulte et al. 2005). It is of interest to see how responses vary with different rationales for a water tariff increase.

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About the Paper

Yi Jiang, Leshan Jin, and Tun Lin estimate the willingness-to-pay (WTP) of Fuzhou urban residents for Min River upstream water pollution under a payment for environmental services scheme. They find that mean WTP varies from CNY -0.45 per cubic meter to CNY0.86 across different incomes. On average, urban residents are willing to pay CNY0.21, equivalent to 10% of the existing water tariff, for upstream water pollution reduction in Fuzhou, where annual per capita income is near CNY20,000.

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