GREDI
Groupe de Recherche en Économie
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Cahier de Recherche / Working Paper
15-04

Spatial heterogeneity and transboundary pollution: A contingent valuation study on the Xijiang River drainage basin in south China

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This version March 2nd, 2015

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Abstract

This article examines whether and how transboundary river water pollution spillover may affect resident's Willingness to Pay (WTP) for a river water quality improvement project. Based on a CVM survey conducted in 20 cities located in the Xijiang river basin located in south China, our study demonstrates that the downstream city respondents report lower WTP when the water quality in the immediate upstream city is more polluted. This negative externality decreases with distance and relative bargaining power of downstream city. The simulated potential gain in social benefit if an integrated river basin management (IRBM) were installed, which is supposed to remove respondents' concerns about negative externality of transboundary river pollution is found to be significant. We can consider this social benefit as upper bound for the transfer from downstream to upstream regions to ensure the reduction of transboundary river pollution spillovers in the Ecological Service Payment (ESP) regime, a hotly debated market-based environmental policy which is under polit project in some regions in China.

Keywords: transboundary water pollution, river, negative externality, spatial, contingent valuation, river water management, ecological service payment, China

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1. Introduction

Stated preference non-market valuation methods are often used to assess public preferences for environmental quality improvement policies or projects. Although spatial characteristics may play an important role in willingness-to-pay (WTP) determinations (e.g., Bockstael, 1996; Johnston et al. 2002, Bateman et al. 2006), the growing trend of considering spatial characteristics in stated preference studies is relatively recent, with the earliest studies of this type traced to Desvousges et al. (1987) and Bockstael (1996). Johnston et al. (2002) suggested that "[the] omissions [of spatial factors] may be particularly troubling in case where the survey instrument itself provides cartographic details that respondents may associate with particular spatial characteristics." Several of the conventional WTP determinants, which vary from initial environmental conditions to specific economic characteristics (Bateman, 2009), can present large degrees of spatial heterogeneity and may therefore diverge WTP values for a same environmental quality improvement project held by residents living in various locations.

Spatial preference heterogeneity can be potentially important for the river water quality related valuation studies. As large-scale generic resources, rivers often flow across political jurisdiction boundaries (communities, cities, provinces and even nations). When territories on both sides of a boundary apply different environmental policies and exhibit differences in geographical and economic conditions, water quality levels across boundaries may not be uniformly and continuously distributed but instead may be inconsistent and discrete (Jørgensen et al., 2012). Previous studies by Moore et al. (2011), Tait et al. (2012) and Lanz and Provins (2013) have found respondents' WTP to be dependent on the initial environmental quality and other related characteristics which are spatially variable. They defined these phenomena "spatial scope sensitivity."

In addition to "spatial scope sensitivity," another factor that may also affect WTP in a spatial manner is transboundary pollution, a phenomenon that is closely related to public characteristics of river water. River flows create upstream and downstream regions. Administrative boundaries between regions, however, do not prevent pollution from crossing regional borders. Without a uniform water quality standard applied to the entire river system that respects the basic Samuelson condition, a polluting upstream region, not able to enjoy the full benefits of pollution control, may not exert sufficient control of pollution discharge into the river. Oates and Portney (2003) further indicate that such a situation can even result in a race to the bottom of regional water quality control policies along a river. In such situations, all else being equal, the further downstream a person lives along a river, the stronger his/her doubts will be with respect to possibilities for enjoying proposed water quality improvement and the lower WTP levels will be as a result.

Though it has not yet been investigated in the valuation literature, the existence of river-level transboundary pollution has already been confirmed at the international and province/state levels in studies that directly focus on the spatial distribution patterns of river water pollution concentration. Sigman (2002) used GEMS/Water[1] biochemical oxygen demand (BOD) data measured by 291 river monitoring stations in 49 countries during 1979-1990 and found the BOD indicator to be significantly higher at stations upstream of borders than comparable stations, at least among stations located in non-European Union (EU) countries. As most US federal environmental policies assign regulation, implementation and enforcement responsibilities to the state level, Sigman (2005) also investigated potential

[1] The UN's Global Environmental Monitoring System Water Quality Monitoring Project.

transboundary spillover phenomena occurring within the US using a composite water pollution index based on five major pollutants compiled from 618 monitoring stations from 1973-1995. Applying difference-in-difference logic, Sigman (2005) found water quality indexes to be 4% worse at stations downstream from a state that is authorized to implement and enforce environmental regulations, all else being equal. Using GIS water quality panel data from 321 monitoring stations across Brazil as well as jurisdictional boundary modification data for 5,500 Brazilian counties, Lipscomb and Mobarak (2008) studied whether water quality across jurisdictional boundaries deteriorates due to the concentration of polluting activities in a river's exit point out of a jurisdiction. Their results confirmed that within 5 kilometers distance to the boundary, pollution increases by 2.3% for every kilometer closer a river gets to the exiting border. The transboudary air pollution was also studied in the past. One exemple is Helland and Whitford (2003), which examined a transboundary air pollution spillover incidence that occurred in the US and revealed higher toxic chemical levels in border counties.

The principal hypothesis of this paper is therefore that the geographic location of a respondent along a river basin significantly affects his/her demand for a river water quality improvement project. We assume that while considering his/her WTP for the project, a respondent will not only include current river water pollution situation and other related social and economic conditions of the region where he/she resides, but also be concerned by the situation of upstream regions. To test these hypotheses, the study applies the Contingent Valuation method (CVM) to examine the factors that affect respondent willingness to pay (WTP) for a hypothetical river water quality improvement project. Our CVM survey was conducted in 20 cities of four provinces of southern China belonging to Xijiang river basin from July to August, 2012. The Xijiang River provides an interesting case for spatially related study, as regions along this river have demonstrated considerable disparity in economic development and environmental pollution over the last several decades. Double bound dichotomous choice (DC2) and multiple bounded discrete choice (MBDC) WTP questions were randomly presented to local residents of the 20 cities. City-level macroeconomic and river water quality data were used in our econometrics models in combination with individual-level socio-economic characteristics to measure the spatial factors that cause heterogeneity in WTP between respondents living in different locations along the Xijiang River. To test the existence of transboundary pollution phenomena and their impact on people's WTP, particular attention was given to whether and how water quality and polluting economic activities of upstream cities affect the preferences and perceptions of respondents living in downstream city about the same river quality conservation project.

A central finding of this study is that, although, respondents living in cities with high levels of polluted river water are in general willing to pay more; all else being equal, those living in downstream regions report lower WTP if the water in their immediate upstream city is more heavily polluted. We also tested the robustness of our results by adjusting the influence of upstream city water quality according to the logic of "distance-decay" and under conditions of varying relative bargaining power for adjacent downstream cities. These tests generated stable results. The findings reveal the necessity of considering inter-relationships between regions positioned along the same river in CVM studies that examine river basin-level water quality improvement projects, in the aims to account for negative externalities from river water pollution.

Based on the estimation results, we also simulate the potential gain in social benefit if an integrated river basin management (IRBM) could be installed, which will remove respondents' concerns about negative externality of transboundary river pollution. In total, the increase in social benefit is found to be quite significant. The simulated social benefit increase can also be considered as an upper bound for the amount that a downstream region would be willing to pay for avoiding the transboundary river pollution spillovers via the so-called Ecological Service Payment (ESP) regime, a market based transboundary river water pollution control mechanism currently hotly debated in China.

The paper is organized as follows: in Section 2, we review spatial factors related to the stated preference valuation literature. Section 3 outlines the river basin-level transboundary pollution situation in China. Section 4 presents a background on the Xijing River Basin. Sections 5 and 6 describe the survey and data cleaning methods. Section 7 elaborates on the principal hypotheses tested under the river transboundary pollution scenario. The models, estimation results and robustness check are described in Sections 8 and 9. Finally, we provide a discussion in Section 10 on the pertinence and policy implications of our findings in relation to China's pilot ecosystem service compensation mechanism, which aims to reinforce transboundary coordination for river pollution control. Finally, Section 11 provides a conclusion.

2. Literature Review

Spatial factors have received increased attention in recent stated preference (SP) environmental valuation studies.[1] This research interest is mainly motivated by the potential of spatial preference heterogeneity. Spatial preference heterogeneity can affect the size of economic jurisdictions in which relevant residents exhibit positive WTP (Bateman et al. 2006; Hanley et al. 2003) and the value of WTP (Bateman et al. 2006; Pate and Loomis, 1997; Bockstael, 1996). As the aggregation of total benefit for non-market goods often relies these two factors, several researchers believe that a failure to control spatial heterogeneity can negatively affect aggregate WTP precision. Bateman et al. (2006) found that the aggregate WTP value based on "economic jurisdictions" to be sixteen times smaller than the value of simple aggregate WTP based on the "geographical jurisdiction".

The most frequently discussed aspect of spatial heterogeneity in the literature is the so-called "distance-decay" (Loomis, 2000), which suggests that WTP values decline with an increase in distance between a respondent's place of residence and the site providing ecosystem services (Schaafsma et al.2013). Various theories have been proposed over the past decade to explain/interpret the phenomenon of distance-decay. Sutherland and Walsh (1985) argue that information about a valuated site positively motivates WTP levels. They thus conclude that longer distances can result in higher cost for obtaining information on a site, which in turn reduces WTP levels. Hanley et al. (2003) note the necessity to differentiate between users and non-users and found that more rapid processes of distance decay occur with use values than with non-use values. Bateman et al. (2006) highlighted potential differences in distance decay processes through an examination of equivalent loss studies that examine preservation values as well as compensation surplus studies that estimate environmental improvement values. As it is more likely for non-users to become users in environmental improvement projects while a non-users are more likely to become users among households positioned closer to a resource, Bateman et al. (2006) suggest that distance decay trends can occur among both users or non-users, at least within compensation surplus studies. Other authors have attempted to describe the process of distance decay as a

[1] Past studies have addressed numerous spatial attributes and their impacts on resident preferences with respect to ecological goods and services provided by large-scale ecosystems such as rivers (Desvousges et al., 1987; Holmes et al., 2004; Zhiqiang et al., 2002), forests, wetlands and other ecosystems (Broch et al., 2012; Guimarães et al., 2011; Zhongmin et al., 2003).

consequence of substitute availability (Brouwer and Slangen, 1998; Hanley et al. 2003; Jorgensen et al., 2013 and Schaafsma et al., 2013). As the number of substitutes often increases with increasing distance from the valued site, greater distances will correspond with lower demands on the valued site and lower WTP levels as a result. Schaafsma et al. (2012) attempted to further refine this logic by identifying directional heterogeneity in substitute availability, which can affect the distance decay phenomenon in heterogeneous ways in different directions. Finally, certain authors (Sutherland and Walsh, 1985; Rolfe and Windle, 2010, Jorgensen et al. 2013, among others), underscoring the necessity of distinguishing between generic non-market resources (i.e., wetland regions of a country) and an iconic resources (i.e., Yellow Stone National Park or the Great Barrier Reef), show that distance decay is less likely to affect the latter. This occurs because few significant substitutes exist and respondent awareness about these resources is less sensitive to distance.

Similar to the phenomena of distance-decay, spatial scope sensitivity (Lanz and Provins, 2013) is another aspect of spatial preference heterogeneity that has begun to attract the interest of SP researchers. More pertinent to generic natural resources of relatively large geographical scale and non-homogeneously distributed quality/quantity, spatial scope sensitivity allows one to understand how respondent WTP vary according to spatial variability in the quality/quantity of an environmental resource. Johnston et al. (2002) showed that the WTP for a rural land development project is dependent on whether developments are located adjacent to main roads, among other factors. Moore et al. (2011) found WTP for a universal water clarity improvement project in Green Bay, Wisconsin to be dependent on the initial clarity of the water section closest to respondent residences. Because the most polluted sections in Green Bay lie close to the population center, the authors found that their "geospatial referencing model" generates much higher aggregate WTP values for the project than the base mode, which views households as single entities defined only by average water quality in the bay. Tait et al. (2012) combined spatially related water quality data in an experiment choice study using the Geographical Information System (GIS). The authors found that respondents who live in the vicinity of low quality waterways are generally willing to pay more for improvements relative to those who live close to high quality waterways. Broch et al. (2013) found that farmer willingness to provide goods or services is affected by spatially heterogeneity in species richness, human population density, special groundwater interest area share and forest cover and hunting resource share. Their results also confirm the necessity to account for spatial variations in designing conservation policies.

Studies focusing on spatial scope sensitivity have therefore focused more intensively on the characteristics of valued goods and services themselves, as well as geographical variability between these characteristics. These characteristics represent the main difference between spatial scope sensitive studies and studies focusing on distance-decay, which instead focus on distances between individuals and valued goods/services and the availability of substitutes. Naturally, spatial scope sensitivity related studies depend more heavily on the availability of the geographic data that describe spatial differences in either the quality or quantity of valued goods and services. These geographic data also enable studies to provide precise WTP estimations using more detailed geographical scales.

Another category of factors that can cause spatial preference heterogeneity is the potential inter-relationship between respondents of different regions. This is also the source of preference heterogeneity that we will study in this paper. This spatial preference heterogeneity describes the situation in which, an improvement project to a generic natural resource can be viewed in various ways by respondents living in different localities. Brouwer et al. (2010) provide an example of this trend. By assessing the preference heterogeneity for the spatial distribution of water quality improvements throughout a river basin using a choice experiment study, the authors found that irrespective of the sub-basin in which respondents live, improvements of water quality to good levels are valued equally by local and non-local residents. However, when improving water quality level above very good quality, local residents attribute additional value to these improvements if they occur in their own sub-basin. Another interesting example is provided by Lanz and Provins (2013), who explicitly examined how the preferences of respondents change with the location of an improvement project. The authors accomplish this by using policy coverage as an attribute in their choice experiment design. In addition to finding logically strong preferences for local environmental amenity improvements, the authors also observed that an enlargement of the project spatial coverage increases preference heterogeneity across regions while decreasing the mean WTP. The authors conclude that "for some attributes, respondents can display negative surplus for the provision of improvement in other nearby regions, which signals competition for the appropriation of rivalrous benefits" (Lanz and Provins, 2013, p. 107).

Our paper naturally falls under the spatial scope sensitivity literature as people's WTP is assumed to be directly related to their locations along the river. The novelty of this study compared to existing literatures lies in our focus on the inter-relationship between cities/regions along the same river and on how this inter-relationship can directly affect WTP. To our knowledge, it is the first paper that discussed this aspect of spatial preference heterogeneity. Moreover, our study contributes an interesting case study to the empirical river basin transboundary pollution literature such as Sigman (2002, 2005), although the transboundary phenomenon is analyzed in our paper indirectly.

Our study also differs from existing non-market valuation studies that value water related ecological services in China as well as in other developing countries and regions. Such studies include examinations by Wei et al. (2006) focusing on the North China Plain, Yang et al. (2008) on Hangzhou, China, Tong et al. (2007) on Wenzhou, China, Zhiqiang et al. (2002) on the Heihe River Basin in China, Zhongmin et al. (2003) on the Eijna Region of China, Choe et al. (1996) on the Philippines, Vásquez et al. (2009) on Mexico, Boadu (1992) on Ghana, and Hammitt et al. (2001) on Taiwan. These previous studies focused on specific regions/areas rather than on entire river basins. As well, these studies placed limited emphasis on the potential role of spatial factors in value/preference determination.

3. River basin-level transboundary pollution in China

The majority of large-scale river basins in China span several regional jurisdictions (province/region/city). It is therefore evident that decisions made in one regional jurisdiction can have implications across administrative boundaries, as has been reported for the international case as well as for cases in the US and Brazil. From the perspective of environmental regulation, this trend is probable in China because although environmental policy is typically developed centrally while local jurisdictions may only set their own environmental standards to more stringent levels than those of the national level, implementation responsibilities are devolved to the branch office of the Ministry of Environment Protection (MEP), which operates at the provincial, municipal and county levels (Hills and Robert, 2001).

The monitoring and enforcement capabilities of MEP branch offices are largely affected by complexities and fragmentation between the different authorities. Yu (2011) describes the complex relationships between the Ministry of Water Resource Management (MWRM), which addresses water quantity and water utilization, and the MEP, which coordinates and solves transboundary environmental pollution disputes. The author believes that either overlaps or gaps exist between the competences of the two authorities, which may largely compromise the efficiency of their efforts with respect to transboundary river water pollution control. Hills et al. (1998) indicate that inefficiencies in policy enforcement in China can be further compounded by the networking relationships (*guanxi* in Chinese) between regulators and polluters, which can result in erratic and inconsistent enforcement of environmental protection measures. Yu (2011) believes that this is especially true in the current context in which the budgets of lower MEP branches are dependent on local governments, which may assign higher priority to economic growth than to environment protection. Another particularity of the Chinese is that, given a lack of water resources, it is common for each jurisdiction to construct water conservation structures such as dams and floodgates, and this may further enable each region to control the distribution of pollutants within its jurisdiction by dispelling pollutant flows more directly to the downstream jurisdiction (Zhao et al. 2012).

These particularities, along with a shortfall of efficient transboundary pollution agreements and concrete dispute settlement mechanisms, have resulted in severe water pollution levels at transboundary locations (Wang, 1999; Zhao et al. 2005; Yu, 2011; Zhao et al. 2012). Examples include the blue-green algae outbreak in the Taihu Lake Basin in May of 2007 (Zhao et al. 2012) and the well-documented transboundary pollution levels between Guangdong Province and Hong Kong via the Pearl River drainage basin (Hills and Roberts, 2001; Hills et al. 1998, Marsden, 2011, among others).

4. Background on the Xijiang River Basin

The Xijiang River is the main channel and longest tributary of the Pearl River, which is the largest river system in southern China. The river flows for 2217 kilometers from the north of Yunnan province eastward across two southern provinces of China (Guizhou province and Guangxi province) and through the Pearl River delta in Guangdong province, finally terminating at the southern China Sea near Macau.

The Xijiang River basin accounts for 78% of the Pearl River basin area (409,480 km^2), and it drains the majority of the Southern provinces as well as parts of southwestern China. According to the 6^{th} nationwide population census of China (conducted in 2010), the population living within the Xijiang River basin is approximately 100 million. The regions belonging to the basin are important in terms of economic activities, contributing an annual gross output of 3,790 billion Yuan (2010) and an annual growth rate of over 10% by 2012. The river basin covers the most developed area of southern China.

Over the last 35 years, the Xijiang River Basin, similar to other regions in China, has experienced trends of increasing inequality with respect to economic development. Taking the provinces Guangdong and Guangxi as example, in 1978, before the start of economic reform, Guangdong's gross regional output (GRP) per capita was 370 Yuan (220.24 USD), which was approximately 1.5 times higher than that of Guangxi (246 Yuan, equal to 146.43 USD). However, in 2008, Guangdong's GRP per capita had reached 37589 RMB (5408.49 USD), which was approximately 2.5 times higher than that of Guangxi (14966 RMB, equal to 2156.48 USD).[1] Along with increasing disparities in per capita GRP, increasing disparities between the two provinces also occurred with respect to economic structure, urbanization levels, and economic openness, among other variables.

[1] Conversions between RMB and USD are conducted using the official exchange rate, which was 1 USD=1.68 CNY in 1978 and 1USD=6.95CNY in 2008.

Uneven development between regions naturally leads to considerably different interpretations of the role of regional government in determining the relationship between the environment and the economy. Although a wave of environmental consciousness has begun to surface in some of the richest eastern coastal provinces/cities, several western inland regions are still willing to endorse environmental damage in the interest of attracting investment in polluting productive sectors. Such a situation may further exacerbate the above mentioned transboundary pollution problem because a particularity of the Xijiang river basin is that most of the poor inland provinces/cities, which are willing to sacrifice the environment for growth, are located in upstream from the Xijiang river basin. Such a situation may unfortunately be further enhanced by the fact that the two inland provinces (Yunnan and Guizhou) located upstream from the Xijiang River basin are rich in nonferrous metal reserves. Extraction practices for this resource are highly polluting and especially polluting of water resources either directly through the discharge of mining wastewater or indirectly via extraction-related deforestation and soil-erosion/contamination. Accumulated levels of industrial wastewater pollution further contribute to enormous domestic wastewater discharge outputs and water demand pressures in adjacent cities. All of these factors have contributed to the deterioration of Xijiang River water quality, and especially in downstream cities.

5. Survey

To measure the WTP value for the ecological goods and services provided by the Xijiang River, we conducted a large-scale, cross-regional CVM survey in 20 cities of four provinces (Guangdong, Guangxi, Guizhou and Yunnan) along the Xijiang River from July to August of 2012.

The questionnaire design benefited from the discussion of a series of focus groups composed of researchers, students and experts (both academic and operational) working in hydrologic and geographic fields. A pre-test was conducted in Guangzhou city with the participation of over 50 respondents randomly solicited. Their comments on the questionnaire were incorporated in the development of the final questionnaire.

The final version of the questionnaire is divided into three sections: (1) the general understanding and attitudes of the respondents toward the current condition of environmental and Xijiang River water pollution in the vicinity of the sampled city, (2) a description of a hypothetical scenario proposing water quality improvements and the elicitation question on the respondent's willingness to pay and (3) respondent socioeconomic and demographic information and their predictions in relation to changes in income and welfare if the hypothetical scenario were realized.

To ensure understanding among the respondents on the different levels of water quality, the survey used the graphical illustration of the water quality ladder that was initially proposed by Mitchell and Carson (1989). The river basin-level uniform water quality improvement target is fixed at the swimmable level (C level as illustrated in annex 1), which corresponds to level II of the Chinese Ministry of Environment Protection classification. [1]

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[1] While more recent water quality ladder designs such as the 4D-image version proposed by Hime et al. (2009) were also considered while designing the questionnaire, we used the classical version provided by Mitchell and Carson (1989) due to its simplicity. Moreover, given the current low water quality in Xijiang, certain elements proposed in the water quality ladder by Hime et al. (2009) are less relevant as a large proportion of the possible ecological services are currently either weak or absent in the Xijiang River. Furthermore, limited recent experiences with cleaner river water environments may have also affected respondent understandings of certain ecological services proposed in the water quality ladder by Hime et

Before the WTP questions, the respondent were firstly provided with a general description about the current and future water quality for Xijiang River, in which the potential contribution of transboundary pollution and the reallocation tendency of polluting industrial production toward upstream cities were explicitly mentioned.

> "The Xijiang River drainage basin covers four provinces, Yunnan, Guizhou, Guangxi and Guangdong provinces. Although the water quality of Xijang River is relatively better than other large rivers in North China, since several years, major pollution incidents frequently happened on its tributaries, affected directly health and safety of people living along the river. Given the rapid economic and social development in cities along the Xijiang River and the already observed tendency of reallocation of polluting industrial production toward upstream cities, many researchers expected large-scale deterioration of water quality in Xijiang River drainage basin in near future."

Following, the current water quality of the section of Xijiang River flowing through the city where a respondent lives was presented with the help of the water quality ladder.

Two WTP elicitation strategies were used in split samples of respondents. Fifty percent of the respondents were given a double-bounded dichotomous choice (DC2) WTP question while the other 50% answered the WTP question via a multiple bounded discrete choice (MBDC) matrix. Both questionnaire versions share the same 14-bid price range, which varies from 0 to 500 yuan.

For the DC2 questionnaire, respondents were first asked the following question: "would you pay ___ Yuan for a program that would improve the water quality of the Xijiang River to swimming level(level C)?" Depending on a respondent's answer to this question, a higher/lower bid price was proposed. Table 1 presents the 14 groups of alternative bids used for the double-bidding regimes.

In the MBDC format questionnaire, the respondents were invited to fill out the matrix by indicating their propensity to accept each of the 14-bid prices, c.f. Table 2.

To ensure a uniform and efficient sampling strategy for the 20 cities, we conducted face-to-face intercept surveys in public locations. Waiting areas in outpatient sections of hospitals were identified as appropriate places given the large traffic flows and relatively even distribution of individuals across different social classes that frequent these areas. Thirty students from four universities (Sun Yat-sen University of Guangdong Province, Zunyi Medical College of Guizhou Province, Guangxi Normal College of Guangxi Province and Yunnan University of Yunnan Province) were recruited and trained to administer the survey.

Stratified random sampling was employed to ensure an appropriate balance of representativeness across the surveyed cities. The sample size for each city was determined to be roughly proportional to its total population size. The sample sizes for the 20 cities are given in Table 3. A total of 2223 questionnaires were returned. After removing responses from respondents under the age of 18 as well as those that had lived in the sampled city for less than three years (to ensure respondents possess sufficient knowledge on the city's environmental situation), we obtained a total 2133 usable questionnaires, in which 1090 had been presented with the DC2 questionnaire and 1023 had been interviewed through MBDC questionnaire.

A comparison of respondent socio-demographic characteristics between the two subsamples presented in Table 4 demonstrates fairly high levels of similarity, with the exception of the average education variable, as respondents that answered the MBDC questionnaire had undergone an average of 0.7 more years of schooling.

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al. (2009).

Table 5 presents a comparison between the studied provinces on the basis of population census data. Across the four provinces, the biggest differences lie in average income and education levels. Consistent with regional disparity patterns across China, the respondents from Guangdong province, representing the richest province in southern China, enjoy the highest levels of income and education. Owing to the presence of rich natural resources, respondents from Yunnan province also report relatively high incomes but the lowest education levels. The respondents from Guizhou and Guangxi generally exhibited considerably lower incomes, although education levels are only slightly lower here than in Guangdong.

With respect to census statistics, the gender distributions of the respondents are relatively balanced for three of the four provinces. Yunnan represents the exceptional case, in which male respondents are over-represented (62.37% vs. 50.85%). Well-educated individuals are overrepresented in all four of provinces. This bias may be attributed to three reasons. First, our survey was carried out only in urban areas, where populations are generally more educated. Second, the survey mode that we selected may have discouraged less-educated individuals, who may have averse being interviewed by university students. Finally, respondents may have tended to over-report their education levels because the interviewers were college students. A similar but less critical bias of our sample population was concerned with age. Table 5 shows that our sample was heavily skewed towards the younger generation, with the majority of respondents being between 20 and 40 years old. This may also be attributed to the face-to-face survey mode.

6**. Data cleaning for WTP responses**

The data-cleaning based on WTP answers is illustrated in table 6. Among the 1023 respondents of the MBDC survey, 119 respondents expressed negative answer at a bid of zero. Ninety-nine respondents provided positive answer at the highest bid price of 1000 Yuan. Another 120 respondents returned questionnaires with missing values in the MBDC matrix, which rendered these data unusable. We found only one disordered answer to the MBDC matrix, which demonstrates the relatively good understanding of respondents about the logic of the MBDC questionnaire. For the 1090 respondents of the DC questionnaire, 143 individuals demonstrated a negative intention to accept the project at a bid of zero, and 37 respondents gave positive answers at the highest bid price. We also find sixty-three questionnaires with missing answers.

The negative answers at the zero bid and positive answers at the highest bid can be further classified according to the answers to the two follow-up questions. As illustrated in Table 7, among the 119 negative, zero-bid answers, 102 can be labeled as protesters (9.74%). Within this group, the majority of respondents (87 persons, 8.3%) expressed doubts that the fund would be used properly while 15 persons (1.44%) believed that the government should be held responsible to support the project financially. The remaining 17 respondents expressed weak demands that included the following motivations: little importance attributed to the project (3 persons) and potential heavy financial burdens of such a project on family expenditures (14 persons). For these respondents, we assigned a WTP value of zero. For the DC2 data, we identified 82 protest answers: 76 expressed low confidence in the fund management, and six others believed that such efforts should be funded by the government. The other 61 persons are assigned as real zero WTP responses. Among the various reasons that motivate the extremely high demand responses (c.f. Table 8), 73 (=31+42) responses given in the MBDC format questionnaire and 35 (=9+26) responses to the DC questionnaire can be considered unreliable.

The frequencies (in %) of the five probability responses to the MBDC for each bid price are summarized in Figure 2. The percentage of ‘definitely yes’ answers sharply decreases from approximately 92.6% at the zero-bid price to less than 1.2% at the 200 yuan-bid price. The percentage of ‘definitely no’ answers increases steadily with the bid price, from 0% at the zero-bid price to approximately 95.2% at the 1000 yuan. Among bid prices ranging between 20 and 150 yuan, approximately 50% of the respondents selected the ‘probably yes/no’ or ‘not sure’ response options, illustrating relatively high levels of uncertainty in WTP answers. We therefore decided to use the two-stage Random Valuation Model (RVM) approach proposed by Wang and He (2011) to estimate the WTP determination function, which assumes that the responses provided by an individual via the MBDC matrix can be directly interpreted as the verbal likelihood for him/her to accept the corresponding bid prices.[1]
Table 10 presents the percentage of “yes” responses for each bid price proposed in the DC2 version of WTP question. The percentage listed in bold type presents the acceptance rate for the initial bids. The number listed above (below) in the same column reports the acceptance rate for the bid-decreasing (-increasing) path. Within any column, the expected negative relationship between bid amount and acceptance probability is obtained. However, reading across the rows of the table, we can observe clearly that there is a positive relationship between probability of bid-acceptance and the initial bid amount. This means that, at any given bid amount, the probability of accepting the bid is greater for respondents with relatively high initial bid amounts than for those with relatively low initial bid amounts. Following DeShazo (2002), we further calculate for each initial bid price:

P(Y): proportion of respondents answering “yes” at initial bid
P(Y|Y): proportion of respondents answering “Yes” after accepting the initial biding (ascending)
P(N|Y): proportion of respondents answering “No” after accepting the initial biding (ascending)
P(Y|N): proportion of respondents answering “Yes” after refusing the initial biding (descending)
P(N|N): proportion of respondents answering “No” after refusing the initial biding (descending)
P(N): proportion of respondents answering “No” at initial biding

The comparison of the six proportions is summarized in the three panels in Figure 3. Based on the hypothesis of DeShazo (2002, Table 1, page 368), we are relatively confident that the internal inconsistence between the two answers given by respondents in the biding games is more close to an anchoring effect. We therefore used the model proposed by Herriges and Shogren (1996) to capture the anchoring effect caused by the initial bid.[2]

7. Hypotheses to be tested

[1] During the first stage we therefore used this information to estimate individual WTP distributions, whose mean values signify real individual WTP and variance measures individual uncertainty. The benchmark verbal likelihood coding strategy for our analysis is 1.00 for “Definitely Yes,” 0.75 for “Probably Yes,” 0.50 for “Not Sure,” 0.25 for “Probably Not,” and 0.00 for “Definitely Not.” The specifics of the estimated individual mean WTP (μ_i) distributions and the standard variance (σ_i) for the entire sample are given in annex 3. During the second stage, the estimated individual mean WTP was regressed directly for the identified WTP determinants using a linear function form. The results corresponding to Wang and He (2011) presented in the main text are those from the second stage. The details about the Wang and He (2011) approach is provided in annex.

[2] The details of the model for estimation based on Herriges and Shogren (1996) is provided in Annex.

Based on the discussion presented in the introduction and literature review, we test the following four hypotheses in this paper. First, considering spatial differences in current river water pollution conditions, we follow the logic of spatial scope sensitivity in a similar manner as Moore et al. (2011) and Tait et al. (2012) by considering the $WTP_{i,k}$ of a respondent i from city k to be dependent on the current water pollution condition of the segment of river flowing through his/her city, P_k. Because higher pollution levels should correspond with higher levels of WTP, we expect a positive coefficient for this variable.

$$H1: WTP_{i,k} = f\left(\underbrace{P_k}_{+}\right) \text{ for all i living in city k}$$

Second, given the transboundary water pollution problem, we also assume that the WTP of a respondent i living in city k is dependent on the pollution condition of the direct upstream city j. A more severe water pollution condition in the upstream city will discourage respondent's WTP by a negative-externality-style effect. More precisely, if a respondent believe a poor upstream water quality may reduce the probability of meeting the water quality targeted in their own city, their WTP should be lower, all else being equal. We therefore expect a negative correlation between the $WTP_{i,k}$ value and the river water condition of the upstream city, P_j.

$$H2: WTP_{i,k} = f\left(\underbrace{P_j}_{-}\right) \text{ for all i living in city k, j is the direct upstream city for k}$$

Third, we further assume that the impact of transboundary water pollution on WTP for respondent i living in city k described in H2 will follow the pattern of "distance-decay." Therefore, the negative externality of the water pollution condition of upstream city j on respondent i WTP in city k decreases with the distance along the river that separates the two cities j and k. To capture this distance-decay effect, we use a cross-term between P_j and the river distance between j and k $D_{j,k}$, in which the distance is entered as an adjustment term $\frac{1}{1+D_{j,k}}$. When city j and k share a border that the Xijiang River flows through, the cross term adopts the entire impact of P_j, as in H2. When river distance exists between j and k, the negative externality of P_j on $WTP_{i,k}$ is mitigated by the distance that separates the two cities. Moore et al. (2011) used a similar term in her measurement of distance decay. We expect a negative coefficient for this cross-term.

$$H3: WTP_{i,k} = f\left(\underbrace{P_j \times \frac{1}{1+D_{j,k}}}_{-}\right) \text{ for all i living in city k, j is the direct upstream city for k}$$

Fourthly, we also believe that respondent i's WTP for the proposed water quality improvements is dependent on the bargaining power of his/her city k in relation to upstream city j. A higher bargaining power of city k with respect to upstream city j may help to ensure better collaboration of upstream city j, therefore reduce the influence of the transboundary water pollution on people's WTP. Therefore in H4, we also add into the cross-term with P_j the ratio of the bargaining power of two cities $\frac{bargain_j}{bargain_k}$. With an expected negative coefficient, a higher level of bargaining power in city k compared to that of the upstream city j will reduce the impact of P_j on $WTP_{i,k}$. Considering the bargain between upstream and downstream cities in our case is to avoid the negative impact of transboundary water pollution, therefore higher is the stake for the downstream city relative to its upstream neighbor, higher should be it bargaining power. We believe therefore the population size of a city to be the most relevant measurement for bargaining power, since a larger size of population in city j signifies a larger negative impact of transboundary pollution. A second relevant measurement of bargaining power is the GDP growth rate. Given the capital/population mobility between cities is very often dependant on the city-level growth rate, we believe higher is the GDP growth rate of a city, higher will be its potential to attract labor and investment. Therefore, to avoid the decrease in its attractiveness to labor and investors, a downstream city with higher GDP growth rate should have interest to bargain harder in a negotiation with its upstream neighbor.

$H4\colon WTP_{i,k} = f\left(\underbrace{P_j \times \frac{1}{1+D_{j,k}} \times \frac{bargain_j}{bargain_k}}_{-}\right)$ for all i living in city k, j is the direct upstream city of k

8. Estimation

The estimation of WTP determination model was separately conducted for the two split samples and the results are presented in Tables 11 and 12. For each model, the results for the four hypotheses are presented. As we applied two different proxies of relative bargaining power (relative population size, pop_j/pop_k and relative economic growth rate $gdpgwr_j/gdpgwr_k$), the results corresponding to H4 are presented in two columns, with each corresponding to one of the two proxies of relative negotiation power. The estimation results obtained by Wang and He (2011) approach applied to MBDC database reported statistically more significant results. Although the estimation results for DC2 data were relatively weak in terms of statistical significance, it is easy to observe a good coherence between the two tables for the coefficients of most variables and between the estimated mean WTP. This actually reveals good stability of our WTP determination models. The calculation of the starting point effect (or as in our paper, anchoring effect) as Herriges and Shogren (1996) reported significant and positive coefficients, whose values are ranging around 0.23, which signifies that respondents give first bid a 23% weight in forming information to response the follow-up question, this also validate the use of the Herriges and Shogren (1996) model.

As expected, income (*income_level*) is significantly and positively correlated with the mean WTP value in all six models. Respondents reporting significantly higher incomes than necessary are also willing to pay significantly more. The level of willingness (*will_serve*, varying from 5 to 1) to contribute to environmental protection programs is found to be significantly and positively associated with WTP, which signifies that respondents with a strong will to contribute to environmental protection are willing to pay more. Although only significant in the models with MBDC data, the negative coefficients of the dummy variable (*resp_gov*) reveal that respondents who view environmental protection as the responsibility of the government are generally willing to pay less. The positive coefficient for the *quality_deg* variable indicates that respondents who believe the quality of river water in their cities to have undergone significant deterioration show generally higher WTP levels. The positive *d_fish* coefficient also confirms that respondents who consume fish at least once a month are willing to pay more for the river water quality improvement project. Logically, respondents living far from rivers report generally lower WTP (c.f. the negative coefficient before *far from the river*). The city-level macro-economic variables obtained several significant coefficients: respondents living in cities with higher shares of secondary industry (c.f. *share2nd*) and higher population densities (c.f. *pop_density*) report lower WTP levels in MBDC models but come out to be insignificant in DC2 models. Though not always significant, respondents living in the cities that enjoy higher economic growth rates appear to exhibit higher WTP levels (c.f. *gdp_growth*).

The key variables related to the four hypotheses are grouped in the lower part of the Tables. All variables concerning the four hypotheses have reported expected coefficients, although the statistical significance of the DC2 data results remains relatively low. As assumed in H1, the coefficients associated with river water quality in cities (c.f. *degree*) where respondents live are found to be always positive. This signifies that for the same river water quality improvement target, respondents do base their valuation of the project on the current water quality of their city. Respondents living in the cities characterized by higher degree of water pollution thus demonstrate higher WTP levels. This finding, echoing to the results of Moore et al. (2011) and Tait et al. (2012), reveals the existence of spatial scope sensitivity in CV studies.

Further inclusion of upstream city river water quality levels (c.f. *degree_upper*), as was expected in H2, is found to contribute negatively to WTP levels, which suggests that higher degree of water pollution in the city directly upstream can cause the WTP of respondents living in the downstream city to decrease, all else being equal. One explanation is that respondents believe a poor upstream water quality can reduce the probability of meeting the water quality targeted in their own city. Besides the statistical significance of the coefficients for *degree_upper*, we also employ the LR test to compares the fit of the models with hypothesis 2 (alternative model) to that of hypothesis 1 (null model). The obtained likelihood ratio reject the null model (hypothesis 1: without upstream water quality included) in favor of the alternative model (hypothesis 2: upstream water quality included), but only for the model based on MBDC data.

Adjusting upstream city river quality with distance (H3) also reveal stable and expected coefficients. The inclusion the distance between up and downstream cities $\frac{1}{1+D_{j,k}}$ into the product with upstream city water quality seems to improve the statistical significance of the coefficients the upstream water quality related term, although for the model based on DC2 data, the related coefficient still did not overpass the 95% significance level. The LR test, however, revealed a statistically better fit of the model H3 (alternative model) compared to that of model H1 1 (null model), those both for the MBDC and DC2. This reveals the necessity to include the concept of distance decay into the consideration of the potential transboundary river water pollution in Xijinag drainage basin.

Further including the bargaining power measurements as adjustment into the product with upstream city water quality and distance does not modify the negative coefficient before the upstream city water quality variable. This confirms H4 that a downstream city that possesses, compared to its direct upstream city, relatively higher bargaining power (measured by either a larger population size or a faster economic growth rate) can reduce the concerns of their residents about the negative externality effects of transboundary pollution, therefore lead to a higher WTP for the water quality improvement project. For the bargaining power measured by relative economic growth rate of up and downstream cities, its participation into the multiplicative term with upstream water quality is found to reinforce the statistical significance of the negative coefficient before the transboundary pollution related terms. This is not only true for the models applied to MBDC dataset (c.f. LR and student value of the coefficient) but also for those applied to DC2 dataset (c.f. LR test).

9. Robustness check

In our survey, we only mentioned the potential danger of transboundary water pollution in Xijiang drainage basin, but did not provide respondents with the exact information about the water quality pollution situation in their direct upstream cities. One question people may ask is whether it is pertinent to suppose the respondents know exactly the level of water pollution in their upstream city. To further test the robustness of the negative impact of transboundary pollution on WTP, we will use two variables as proxy for the water quality of upstream cities. The first is the distance-weighted sum of industrial output of all upstream cities with respect to city k. The underlying reasoning is that industrial wastewater emissions represent an important source of river water pollution, and wastewater emissions are positively correlated with industrial output. For a respondent of city k that does not possess precise information on the pollution flowing from upstream city j, he/she may extrapolate it by using the total industrial production scale belonging to all upstream cities of city j (i=1, 2,…j-1) and that of city j itself. At the same time, river's auto-purification function also leads concentration of pollutants to decrease. We therefore use inverse distance ($\frac{1}{1+D_{i,j}}$) as a weight to simulate the auto-purification procedure between a city i and city j. The industrial output variable used in the paper as proxy of upsteam city river water pollution situation is therefore calculated as:

$$ind\_out\_upstream_k = \sum_{i=1}^{j}[\frac{1}{(1+dist_{i,j})} \times ind\_out_i]$$

Where $dist_{j,j}$=0 and $dist_{i,j}$ signifies the length of river between city j and its upstream city i. City j is the upstream city of city k.

Parallel to the upstream pollution proxy related to industrial production scale, another important source of river water pollution is everyday life wastewater. We therefore also replace upstream water quality with the distance-weighted sum of the population for all upstream cities along the Xijiang River. The distance weighted sum of the population as a proxy for upstream city water quality is therefore calculated as:

$$pop\_upstream_k = \sum_{i=1}^{j}[\frac{1}{(1+dist_{i,j})} \times pop_i]$$

The related results using these two proxies are given in Table 13-16. It is evident that the signs of coefficients for proxies and their adjusted variants demonstrate stable and expected coefficients as those in tables 11-12. Moreover, using industrial output and total population as upstream-city water quality proxies largely improved the statistical significance of the results for the models based on DC2 dataset, therefore provided more convincing evidence of the negative role of transboudary water pollution in WTP determination.

However, some people may still question about the capacity for the respondent to have such precise understanding about the economic and population situations of all upstream cities. Therefore as a final can still capture, although less precise as the previous two proxies, the accumulative nature of the upstream city's river water pollution condition. In addition, we also regard this proxy as a more direct measure of the negative externality related to the difficulty of collaboration between cities facing to transboundary river pollution. From the perspective of a respondent facing the risk of transboundary pollution, the probability for a water quality improvement project to be accomplished is dependent on the number of cities located upstream. A larger number of cities located in the upstream area of a river signifies higher risks of free-riding behavior of the upstream cities, therefore greater difficulties in collaborating between cities to realize the water quality improve target.

The estimate results using this integer count proxy is provided in tables 17-18. Similar to the previous tables, we always obtain the expected negative coefficients for the upstream-city related terms. This signifies that, all else being equal, a respondent reports lower WTP if the number of the upstream cities along the river to be large, and this relationship seemed to be further reinforced when the aspects as distance-decay and the relative bargaining power between cities are included.

10. Policy discussion

The estimation results in last two sections can be considered as an indirect proof of the existence of the transboundary pollution in Xijiang River. One potential solution to resolve such negative externality is to apply the so-called "integrated river basin management, IRBM" (Global Water Partnership, 2000, Millingtonet al. 2006), which involves the process of coordinating conservation, management and development of water, land and related resources across sectors within a given river basin, in order to maximize the economic and social benefits derived from water resources in an equitable manner while preserving and, where necessary, restoring freshwater ecosystems. To measure the potential gain of applying IRBM logic in Xijiang River pollution control, we simulated the city-level mean and aggregate WTP for the hypothetical water quality improvement projects under two distinct scenarios. The first one, the Business as Usual (*BaU*), assumes that transboundary pollution spillover between upstream and downstream cities affects directly a respondent's WTP. The second scenario, referred to as *Integrate* (similar to Brouwer et al. 2010), assumes the existence of an efficient, river basin-level water quality management system that ensures strong collaboration between upstream and downstream regions. Such scenario, if carried out, should be able to reduce concerns held by respondents about the negative externalities caused by transboundary pollution spillovers. For the purpose of comparison, we assume in scenario *Integrate* the coefficients related to transboundary pollution remain at a level of zero.

Tables 19 reports the simulation results for the nine cities located along the main tributary of the Xijiang River. Our simulation is based on the second estimation of H4 (c.f. Table 11 and 12).[1] The values illustrated in the column titled with *BaU* is the simulated WTP value and those inscripted under the column of *Integrate* reveals the variation of WTP owing to the elimination of the concerns about transboundary spillover. As we can see, cities located along the downstream of Xijiang river will experience important increase in their mean and aggregate willingness to pay to the hypothesis water quality improvement, For the cities as Qujing and Yuxi, as they are located at the origin of the river, their residents don't need to concern about transboundary water pollution. In total, the increase in social benefit that can be realized by an *Integrate River Basin Management mechanism* could be quite significant: the estimated social welfare in BaU regime is about 3145.03 million RMB per month in Wang and He(2011)'s model, while in Integrate regime that number will increase by 1132.43 million RMB very month.

Our simulation results on the net social benefits of integrated water quality management systems can also provide interesting insight into the currently hotly debated mechanism of Payment for Ecological Service (PES) (Wang et al., 2006). PES strives to match payments made by downstream residents/regions to the efforts/sacrifices of upstream residents/regions

[1] The choice of the H4 estimation is based on its highest value of the Maximum Likelihood and LR test in the table.

to assure better river-related ecological services. Such a payment mechanism, which can either be ensured through bilateral or multilateral transboundary agreements[1] or through the efforts of a river basin committee, provides a potentially feasible remedy for market failures caused by transboundary river pollution spillovers. Such a mechanism is considered as particularly interesting for the case of China, where the downstream provinces/regions are generally richer and the western inland provinces, locating in the upstream part of the river, facing ever-intensifying industrialization processes and presenting the risk to discharge more and more pollution to the river. In such context, the PES mechanism has been considered by some scholars as a form of “subsidy” transferred from rich eastern regions to their western counter-partners to ensure a more sustainable economic development in these backward inland regions in China. The PES is currently being tested via several pilot projects in large-scale trans-provincial water bodies such as Taihu Lake (Jiangsu and Zhejiang province) and Xin’anjiang River (Anhui and Zhejiang province), where how to determine the amount of transfer stays a difficult question. From this angle, our estimations of total social benefit differences between the *BaU* and integrated water quality management scenarios actually provide some upper bound for the amount that a downstream region could transfer to their upstream regions to avoid the transboundary river pollution spillovers.

11. Conclusion

This paper applies a contingent valuation method to assess the economic benefits of water quality improvement projects in the Xijiang River basin of southern China and provides a detailed analysis of how transboundary river pollution spillovers can affect people’s willingness to pay for river water quality improvement projects. Our results suggest that in addition to individual-level characteristics and city-level, economic and initial environmental conditions, the spatial locations of cities along a river in relation to other cities also exerts significant influence on WTP for water improvement projects. Our results reveal that higher levels of pollution in upstream cities can result in lower WTP among respondents living in the city direct downstream, all else being equal. This WTP diminishing effect is also found to be adjustable by the distance between adjacent upstream and downstream cities and by the relative bargaining power of the downstream city in relation to its direct upstream peer. These findings reveal another pertinent dimension of spatial factors, which is the inter-relationship between regions and their impacts on the benefits that regions enjoy from environmental quality improvement programs.

Although we can consider our results to provide indirect proof of the existence of negative externalities caused by transboundary river pollution spillovers in the case of China, it is still necessary to provide direct evidence of transboundary water pollution in China. This is especially important to support the necessity of establishing a river-basin level water management system in China. Previous similar studies include Sigman (2002, 2005) and an unpublished working paper by Lipscomb and Mobarak (2007). To conduct such a study, detailed and reliable water quality data from monitoring stations along the Xijiang River and locational data for different regional boundaries will be necessary.

Following the logic of cost-benefit analysis, our results for net benefit gains via integrated basin-level water quality management systems can also be compared to potential economic costs/losses that different regions/cities along a river must bear in order to respect uniform

[1] Such agreements exist already between certain provinces. Examples include agreements between the provinces of Zhejiang and Jiangsu with respect to Taihu Lake, the provinces of Qinghai, Gansu and Inner Mongolia Autonomous Region for Heihe River and others (Zhao et al. 2013, Yu, 2011, etc.)

water quality targets. The existing theoretical analyses provided by Van der Laan and Moes (2012) and Ni and Wang (2007) appear to confirm a net gain in social benefit. Although such a comparison could not be carried out in this current study, as we do not possess information on related economic costs/losses for different regions along the river, the results on potential gains presented in our paper offer data that may be used in future studies.

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Fig 1 Map of Xijiang River Basin

Table 1 Alternative Bids for the CVM survey

B	B^l	B^u
3	0	5
5	3	10
10	5	15
15	10	20
20	15	30
30	20	50
50	30	80
80	50	150
150	80	200
200	150	300
300	200	500
500	300	1000

Note: B is the initial bid(monthly voluntary donate, in Chinese Yuan);B^l is second bid if response to first bid was “no”; B^u is second bid if response to first bid was “yes”

Table 2. Matrix used in MBDC WTP question

Price (Yuan)	Definitely not	Probably not	Not sure	Probably yes	Definitely yes
Free					
3					
5					
10					
15					
20					
30					
50					
80					
150					
200					
300					
500					
1000					

Table 3 City Level Sampling Detail

City/region	Population (million)	Sample Size (DC)	Sample size (MBDC)
Guangzhou	12.7	132	140
Shengzhen	10.4	120	114
Dongguan	8.2	84	90
Fuoshan	7.2	72	79
Guiling	7.0	72	76
Nanning	6.7	72	73
Kunming	6.4	72	71
Qujing	5.9	48	64
Guiyang	4.3	48	47
Guigang	4.1	48	45
Zhaoqing	3.9	48	43
Liuzhou	3.8	36	41
Baise	3.5	36	38
Qiannan	3.2	36	35
Zhongshan	3.1	36	34
Wuzhou	2.9	36	31
Qianxinan	2.8	36	30
Yunfu	2.4	24	26
Yuxi	2.3	24	25
Zhuhai	1.6	24	17
Total	108.7	1104	1119

Table 4 Respondents information of MBDC and DC questionnaires

Variable	Description	MBDC mean	DC mean	KW-test
age	The age of respondents	33.27	33.96	1.839
edu	The years of education the respondents has acquired	14.57	13.78	21.579***
income_level	The monthly income of respondents(Yuan)	4101.88	4585.44	1.958
gender	Gender of respondents(1=male,0=female)	0.54	0.52	0.459
N		1043	1090	

***p<0.01,**p<0.05,*p<0.1,Kruskal-Wallis Test's chi-squared Value

Table 5 Comparisons of socio-economic statistics of respondent across provinces

	Guangdong		Guangxi		Guizhou		Yunnan	
	Sample	**Census**	**Sample**	**Census**	**Sample**	**Census**	**Sample**	**Census**
Gender								
Female	49.03%	47.38%	49.60%	48.90%	42.92%	49.10%	37.63%	49.15%
Male	50.97%	52.62%	50.40%	51.10%	57.08%	50.90%	62.37%	50.85%
Education years								
0	0.90%	1.38%	1.00%	1.56%	0.90%	3.32%	0.00%	2.99%
6	0.00%	16.38%	0.00%	17.08%	0.00%	22.56%	20.20%	22.83%
9	8.70%	42.64%	14.50%	35.68%	8.40%	34.71%	8.00%	32.18%
12	23.30%	24.78%	25.60%	25.41%	31.90%	19.65%	29.60%	20.90%
16+	67.00%	14.81%	59.00%	20.27%	58.80%	19.75%	42.10%	21.11%
Age								
20-29	45.86%	34.20%	55.87%	27.15%	40.49%	26.31%	23.48%	24.42%
30-39	29.95%	27.07%	22.50%	25.22%	30.94%	25.91%	31.27%	25.83%
40-49	13.82%	19.72%	12.81%	21.36%	20.04%	21.05%	31.27%	22.90%
50-59	8.38%	9.67%	6.14%	13.37%	7.30%	12.55%	12.59%	12.37%
60+	1.99%	9.17%	2.69%	12.88%	1.34%	14.10%	1.49%	14.45%

Data source: Tabulation On The 2010 Population Census Of Guizhou Province, Guangdong Province, Guangxi Province, Yunnan Province

Table 6. WTP answer data cleaning details

Category	Definition	Number of respondents	
		MBDC	DC
1	WTP value covered by bid price range from 0 to 1000yuan	684	847
2	Negative response at zero bid	119	143
3	Positive response at highest bid (1000 yuan per month)	99	37
4	Missing values	120	63
5	Disordered answers	1	non-applicable
6	Total number	1023	1090

Table 7 Statistics of No demand

	MBDC		DC	
	Number of respondents	%	Number of respondents	%
Reasonable answers				
It is not important to improve the water quality and ecological environment	1	0.096	4	0.4
This kind of donation will put a heavy burden to my family	14	1.34	56	5.1
Others: Have little chance to get in touch with the river	2	0.19	1	0.1
Protest answers				
I don't believe this hypothetic fund will be used properly	87	8.3	76	6.97
Others: Government should take this responsibility	15	1.44	6	0.55

Table 8 Statistics of Extremely High Responses

	MBDC		DC	
	Number of respondents	%	Number of respondents	%
Reasonable high demand				
I can afford 1000yuan per month for environmental protection	5	0.479	0	0
It is very important to protect water resource in this town	8	0.77	0	0
I want to make some contribution to environmental protection	13	1.25	2	0.183
Unreliable high demand				
I am kidding	31	3	9	0.826
Other(1000>one-tens of her or his monthly income)	42	4.03	26	2.385

Table 9 The distribution of answers in MBDC questionnaires

Bid Price	Def yes	Prob yes	Not sure	Prob not	Def not
0	92.6%	4.8%	2.5%	0.0%	0.0%
3	78.6%	14.7%	1.9%	1.6%	3.2%
5	70.8%	17.3%	4.7%	2.5%	4.7%
10	56.5%	22.2%	7.5%	5.2%	8.6%
15	38.7%	23.2%	13.7%	6.8%	17.7%
20	32.5%	18.1%	15.8%	9.8%	23.8%
30	26.8%	14.7%	13.0%	12.0%	33.5%
50	17.1%	15.0%	13.0%	11.4%	43.5%
80	9.2%	12.4%	15.0%	11.6%	51.7%
150	3.3%	6.2%	11.1%	13.1%	66.3%
200	1.2%	2.7%	7.9%	13.0%	75.2%
300	0.3%	1.1%	4.7%	11.9%	82.1%
500	0.1%	0.3%	2.4%	8.2%	89.0%
1000	0.0%	0.0%	0.4%	4.4%	95.2%

Table 10. Cumulative bid acceptance response rate for the 12 initial bid amounts (shown in bold type) and corresponding double-bound trees in DC2 WTP question

Initial bid →	3	5	10	15	20	30	50	80	150	200	300	500
0	95.7%											
3	**88.2%**	80.7%										
5	80.6%	***78.4%***	87.4%									
10		64.8%	**81.1%**	77.5%								
15			70.5%	**67.4%**	75.9%							
20				58.4%	**65.5%**	70.8%						
30					51.7%	**59.6%**	59.1%					
50						40.4%	**48.4%**	52.2%				
80							33.3%	**34.8%**	43.3%			
150								19.6%	**18.9%**	41.8%		
200									13.3%	**28.6%**	32.3%	
300										13.2%	**23.7%**	27.3%
500											14.0%	**15.9%**
1000												8.0%

First row of this table gives the initial bid prices, and the first column gives the corresponding bid price.

Figure 2. Comparison of the proportion of respondents in the three intervals

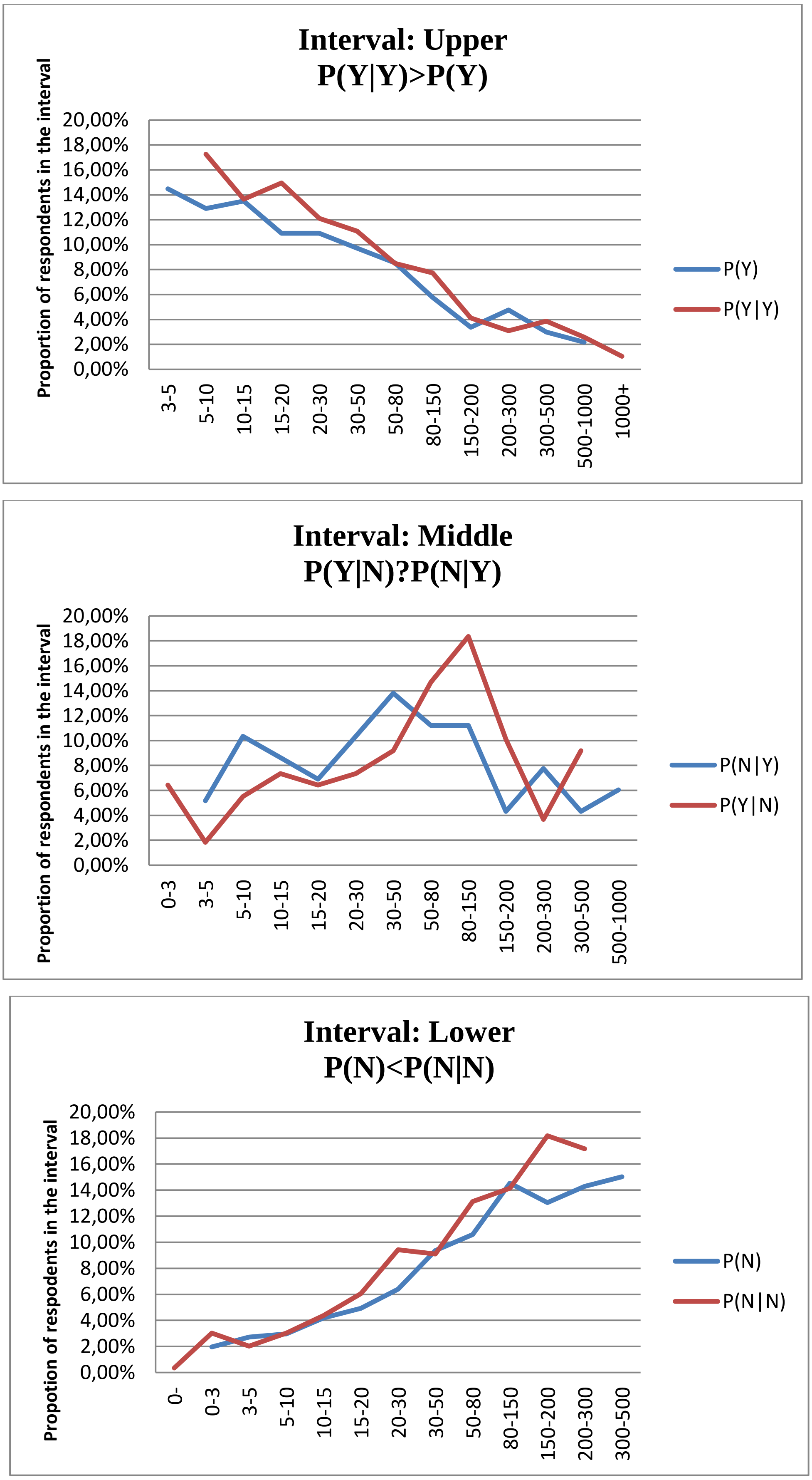


Table 11. Estimation results with spatial factors (Wang and He, 2011 MBDCdata)

	Hypothesis 1	Hypothesis 2	Hypothesis 3	Hypothesis 4	
				Pop as bargain power	Growth rate as bargain power
Bid price	-0.011 (38.13)***	-0.011 (38.13)***	-0.011 (38.13)***	-0.011 (38.13)***	-0.011 (38.13)***
rep_gov	-18.436 (2.19)**	-18.666 (2.22)**	-18.159 (2.17)**	-18.459 (2.20)**	-18.206 (2.19)**
water_problem	7.080 (0.95)	9.700 (1.29)	10.930 (1.46)	8.299 (1.11)	12.074 (1.62)
will_service	15.093 (3.87)***	13.791 (3.51)***	13.203 (3.37)***	13.867 (3.53)***	12.520 (3.21)***
quality_deg	20.245 (2.67)***	20.217 (2.68)***	18.151 (2.41)**	19.499 (2.58)***	17.078 (2.27)**
age	-0.271 (0.79)	-0.177 (0.51)	-0.178 (0.52)	-0.244 (0.71)	-0.182 (0.54)
education	-0.554 (0.46)	-0.614 (0.51)	-0.534 (0.44)	-0.728 (0.60)	-0.440 (0.37)
income_level	4.019 (3.96)***	3.825 (3.76)***	3.988 (3.95)***	3.976 (3.92)***	4.186 (4.17)***
Income significant higher than need	27.176 (2.96)***	27.677 (3.03)***	27.058 (2.97)***	27.845 (3.04)***	26.535 (2.93)***
male	-5.829 (0.81)	-5.859 (0.81)	-5.975 (0.83)	-6.636 (0.92)	-6.558 (0.92)
Can see the river	-25.250 (2.02)**	-24.755 (1.98)**	-24.015 (1.93)*	-24.793 (1.98)**	-23.950 (1.93)
Far from the river	-28.295 (2.38)**	-28.315 (2.39)**	-27.186 (2.30)**	-28.521 (2.40)**	-27.104 (2.30)**
d_fish	10.770 (1.20)	9.815 (1.10)	9.611 (1.08)	9.368 (1.04)	10.231 (1.15)
share2nd	-0.917 (2.29)**	-1.383 (3.06)***	-1.670 (3.63)***	-1.194 (2.83)***	-1.955 (4.17)***
pop_density	-1.011 (2.83)***	-0.580 (1.43)	-0.186 (0.43)	-0.693 (1.78)	0.002 (0.00)
gdp_growth	9.605 (4.16)***	10.790 (4.57)***	9.831 (4.29)***	8.467 (3.57)***	9.086 (3.97)***
degree	5.134 (1.65)*	5.264 (1.69)*	5.990 (1.93)*	5.814 (1.86)**	6.469 (2.09)***
degree_upper		-5.574 (2.22)**			
degree_upper×distance			-13.564 (3.24)***		
degree_upper ×bargaining power ×				-9.626 (2.03)**	-14.444 (4.15)***
Constant	-62.418 (1.27)	-49.903 (1.01)	-28.804 (0.58)	-25.586 (0.49)	-6.201 (0.12)
LR		4.09**	10.45***	4.12***	16.99***
Mean WTP	75.99	75.99	75.99	75.99	75.99
KR CI	[68.89 83.48]	[69.54 82.95]	[69.56 82.93]	[71.14 83.45]	[71.18 83.38]
Ratio	0.19	0.18	0.18	0.16	0.16

Table 12. Estimation results with spatial factors (Herriges and Shogren 1996, DC2)

	Hypothesis 1	Hypothesis 2	Hypothesis 3	Hypothesis 4	
				Pop as bargain power	Growth rate as bargain power
Bid price	-0.007	-0.007	-0.007	-0.007	-0.007
	(6.58)***	(6.57)***	(6.55)***	(6.60)***	(6.53)***
rep_gov	-13.146	-13.691	-14.267	-14.580	-14.209
	(0.91)	(0.94)	(0.98)	(1.00)	(0.97)
water_problem	-2.732	-2.354	-1.707	-2.490	-1.695
	(0.20)	(0.17)	(0.13)	(0.19)	(0.13)
will_service	37.951	37.567	36.715	36.861	36.782
	(4.17)***	(4.13)***	(4.06)***	(4.08)***	(4.05)***
quality_deg	1.859	2.675	1.661	1.530	0.862
	(0.14)	(0.20)	(0.13)	(0.12)	(0.07)
age	-0.182	-0.175	-0.173	-0.200	-0.186
	(0.31)	(0.30)	(0.30)	(0.34)	(0.32)
education	-1.329	-1.319	-1.106	-1.179	-1.060
	(0.70)	(0.70)	(0.58)	(0.62)	(0.56)
income_level	6.495	6.512	6.647	6.557	6.706
	(3.30)***	(3.31)***	(3.34)***	(3.34)***	(3.35)***
Income significant higher	26.264	26.851	28.062	26.712	28.282
than need	(1.62)	(1.64)	(1.71)**	(1.64)**	(1.71)**
male	-5.577	-5.095	-4.876	-5.494	-4.844
	(0.45)	(0.41)	(0.39)	(0.44)	(0.38)
Can see the river	-11.074	-9.95	-8.184	-9.099	-8.248
	(0.49)	(0.44)	(0.36)	(0.41)	(0.36)
Far from the river	-7.295	-4.874	-0.147	-4.055	0.153
	(0.35)	(0.23)	(0.01)	(0.19)	(0.01)
d_fish	6.541	6.204	4.639	5.167	4.597
	(0.42)	(0.40)	(0.30)	(0.34)	(0.30)
share2nd	0.706	0.535	0.208	0.513	0.144
	(0.98)	(0.69)	(0.26)	(0.69)	(0.18)
pop_density	-0.129	0.053	0.505	0.088	0.502
	(0.21)	(0.08)	(0.66)	(0.13)	(0.66)
gdp_growth	2.402	2.984	2.807	1.851	2.359
	(0.61)	(0.73)	(0.71)	(0.47)	(0.60)
degree	7.122	7.111	7.838	7.621	8.059
	(1.37)	(1.36)	(1.48)	(1.45)*	(1.51)*
degree_upper		-2.53			
		(0.58)			
degree_upper×distance			-11.245		
			(1.41)		
degree_upper				-7.635	-9.724
×bargaining power ×				(0.93)	(1.43)
Constant	-163.311	-161.906	-149.080	-143.677	-141.356
	(1.89)**	(1.87)**	(1.72)**	(1.63)*	(1.62)*
Anchor effect	0.237***	0.237***	0.230	0.219	0.230
	(5.68)	(5.65)	(2.04)**	(1.95)**	(2.04)**
LR		0.34	2.094*	0.869	2.176*
Mean WTP	74.44	74.59	74.84	74.41	74.95
KR CI	[50.77.100.24]	[52.27.97.97]	[52.26.98.2]	[52.2.97.72]	[52.35.98.42]
Ratio	0.66	0.61	0.614	0.612	0.615

Robustness check 1: upstream city water quality replaced by the sum of weighted industrial output of all upstream cities (Wang and He, MBDC)

	Hypothesis 1	Hypothesis 2	Hypothesis 3	Hypothesis 4	
				Pop as bargain power	**Growth rate as bargain power**
Bid price	-0.011	-0.011	-0.011	-0.011	-0.011
	(38.13)***	(38.13)***	(38.13)***	(38.13)***	(38.13)***
rep_gov	-18.436	-18.993	-18.096	-17.602	-17.113
	(2.19)**	(2.28)**	(2.19)**	(2.11)**	(2.07)**
water_problem	7.080	10.728	12.229	12.009	14.212
	(0.95)	(1.44)	(1.66)*	(1.61)	(1.92)
will_service	15.093	12.360	11.653	12.437	11.624
	(3.87)***	(3.14)***	(3.00)***	(3.19)***	(3.00)***
quality_deg	20.245	19.431	16.507	18.314	15.555
	(2.67)***	(2.59)***	(2.21)**	(2.44)**	(2.08)**
age	-0.271	-0.275	-0.275	-0.223	-0.251
	(0.79)	(0.81)	(0.82)	(0.66)	(0.75)
education	-0.554	-0.521	-0.212	-0.462	-0.133
	(0.46)	(0.43)	(0.18)	(0.39)	(0.11)
income_level	4.019	4.373	4.911	4.370	4.732
	(3.96)***	(4.32)***	(4.84)***	(4.34)***	(4.71)***
Income significant	27.176	27.382	25.036	25.434	24.340
higher than need	(2.96)***	(3.01)***	(2.77)***	(2.80)***	(2.70)***
male	-5.829	-6.605	-7.636	-6.783	-7.294
	(0.81)	(0.92)	(1.07)	(0.95)	(1.03)
Can see the river	-25.250	-24.270	-23.611	-24.642	-24.316
	(2.02)**	(1.95)*	(1.92)*	(1.99)**	(1.98)**
Far from the river	-28.295	-26.521	-26.661	-27.986	-26.468
	(2.38)**	(2.25)**	(2.28)**	(2.38)**	(2.27)**
d_fish	10.770	12.769	15.865	11.760	13.003
	(1.20)	(1.43)	(1.79)*	(1.33)	(1.48)
share2nd	-0.917	-1.433	-2.079	-2.011	-2.182
	(2.29)**	(3.40)***	(4.57)***	(4.24)***	(4.77)***
pop_density	-1.011	-0.646	-0.510	0.083	0.213
	(2.83)***	(1.76)*	(1.40)	(0.19)	(0.51)
gdp_growth	9.605	7.284	6.921	7.931	8.699
	(4.16)***	(3.07)***	(2.97)***	(3.42)***	(3.83)***
Degree	5.134	5.708	6.595	7.887	7.531
	(1.65)*	(1.85)*	(2.14)**	(2.50)**	(2.44)**
Up-output		-0.000025			
		(3.69)***			
Up-output ×distance			-0.002		
			(5.09)***		
Up-output ×bargaining power × distance				-0.025	-0.016
				(4.18)***	(5.41)***
Constant	-62.418	2.316	28.273	2.938	-2.057
	(1.27)	(0.04)	(0.55)	(0.06)	(0.04)
LR		13.51***	25.45***	17.23***	28.7***
Mean WTP	75.99	75.99	75.99	75.99	75.99
KR CI	[68.89 83.48]	[68.58 82.91]	[68.63 82.86]	[71.18 83.38]	[71.22 83.33]
Ratio	0.19	0.18	0.17	0.16	0.16

Robustness check 1: upstream city water quality replaced by the sum of weighted industrial output of all upstream cities (Herriges and Shogren, DC2)

	Hypothesis 1	Hypothesis 2	Hypothesis 3	Hypothesis 4	
				Pop as bargain power	Growth rate as bargain power
Bid price	-0.007	-0.007	-0.007	-0.007	-0.007
	(6.58)***	(6.55)***	(6.51)***	(6.54)***	(6.50)***
rep_gov	-13.146	-14.374	-13.156	-13.742	-12.994
	(0.91)	(0.98)	(0.90)	(0.94)	(0.89)
water_problem	-2.732	-2.186	-1.147	-0.638	-1.301
	(0.20)	(0.16)	(0.08)	(0.05)	(0.10)
will_service	37.951	36.905	37.234	36.788	37.375
	(4.17)***	(4.07)***	(4.08)***	(4.06)***	(4.08)***
quality_deg	1.859	0.361	-1.546	-1.555	-1.493
	(0.14)	(0.03)	(0.12)	(0.12)	(0.11)
age	-0.182	-0.203	-0.198	-0.190	-0.200
	(0.31)	(0.35)	(0.34)	(0.32)	(0.34)
education	-1.329	-1.022	-0.895	-0.891	-0.905
	(0.70)	(0.54)	(0.47)	(0.47)	(0.47)
income_level	6.495	6.606	6.756	6.667	6.766
	(3.30)***	(3.32)***	(3.34)***	(3.33)***	(3.34)***
Income significant	26.264	28.047	28.771	28.773	28.656
higher than need	(1.62)	(1.70)*	(1.73)*	(1.74)*	(1.72)*
male	-5.577	-5.363	-5.362	-5.582	-5.363
	(0.45)	(0.43)	(0.42)	(0.44)	(0.42)
Can see the river	-11.074	-8.784	-8.573	-7.651	-8.868
	(0.49)	(0.39)	(0.38)	(0.34)	(0.39)
Far from the river	-7.295	-2.325	-0.350	0.134	-0.774
	(0.35)	(0.11)	(0.02)	(0.01)	(0.04)
d_fish	6.541	5.777	5.380	5.092	5.528
	(0.42)	(0.37)	(0.35)	(0.33)	(0.36)
share2nd	0.706	0.514	0.099	0.102	0.121
	(0.98)	(0.70)	(0.12)	(0.13)	(0.15)
pop_density	-0.129	0.077	0.134	0.080	0.108
	(0.21)	(0.12)	(0.21)	(0.13)	(0.17)
gdp_growth	2.402	1.030	1.236	0.812	1.342
	(0.61)	(0.25)	(0.31)	(0.20)	(0.33)
Degree	7.122	7.273	8.420	8.818	8.283
	(1.37)	(1.38)	(1.56)	(1.63)	(1.54)
Up-output		-0.000025			
		(1.28)			
Up-output ×distance			-0.001		
			(1.55)		
Up-output				-0.002	-0.001
×bargaining power ×				(1.80)*	(1.47)
Constant	-163.311	-134.255	-127.670	-120.456	-130.024
	(1.89)*	(1.52)	(1.44)	(1.37)	(1.46)
	0.237	0.237	0.235	0.236	0.235
Anchor Effect	(5.68)***	(5.60)***	(5.52)***	(5.58)***	(5.51)***
LR		1.715	2.598*	3.299**	2.108*
Mean WTP	74.44	74.833	75.15	74.914	75.184
KR CI	[50.77,100.24]	[52.33,98.64]	[52.5,98.96]	[52.37,98.76]	[52.52,99]
Ratio	0.66	0.619	0.618	0.619	0.618

Robustness check 2 : upstream water quality replaced by the sum of weighted population of all upstream cities (MBDC, Wang and He)

	Hypothesis 1	Hypothesis 2	Hypothesis 3	Hypothesis 4	
				Pop as bargain power	Growth rate as bargain power
Bid price	-0.011	-0.011	-0.011	-0.011	-0.011
	(38.13)***	(38.13)***	(38.13)***	(38.13)***	(38.13)***
rep_gov	-18.436	-18.309	-17.942	-18.371	-18.39
	(2.19)**	(2.20)**	(2.16)**	(2.19)**	(2.19)**
water_problem	7.080	11.967	12.021	7.382	8.281
	(0.95)	(1.61)*	(1.62)*	(1.00)	(1.12)
will_service	15.093	11.441	11.63	13.414	13.075
	(3.87)***	(2.91)***	(2.97)***	(3.40)***	(3.32)***
quality_deg	20.245	16.625	16.54	19.43	19.959
	(2.67)***	(2.21)**	(2.20)**	(2.57)**	(2.65)***
age	-0.271	-0.248	-0.268	-0.278	-0.287
	(0.79)	(0.73)	(0.79)	(0.82)	(0.84)
education	-0.554	-0.421	-0.379	-0.798	-0.796
	(0.46)	(0.35)	(0.32)	(0.66)	(0.66)
income_level	4.019	4.475	4.591	4.151	4.203
	(3.96)***	(4.44)***	(4.55)***	(4.10)***	(4.15)***
Income significant	27.176	27.85	26.944	28.503	28.047
higher than need	(2.96)***	(3.08)***	(2.98)***	(3.11)***	(3.07)***
male	-5.829	-6.868	-6.7	-7.457	-6.993
	(0.81)	(0.96)	(0.94)	(1.03)	(0.97)
Can see the river	-25.250	-22.002	-22.49	-24.105	-24.379
	(2.02)**	(1.78)**	(1.82)**	(1.93)**	(1.96)**
Far from the river	-28.295	-23.977	-24.218	-28.118	-27.693
	(2.38)**	(2.04)**	(2.06)**	(2.37)**	(2.34)**
d_fish	10.770	13.295	13.803	10.969	11.339
	(1.20)	(1.50)*	(1.56)*	(1.23)	(1.27)
share2nd	-0.917	-1.2	-1.468	-0.903	-1.139
	(2.29)**	(3.00)***	(3.56)***	(2.26)**	(2.80)***
pop_density	-1.011	-0.811	-0.761	-1.104	-1.068
	(2.83)***	(2.28)**	(2.14)**	(3.08)***	(3.00)***
gdp_growth	9.605	8.853	8.495	7.744	7.485
	(4.16)***	(3.88)***	(3.71)***	(3.19)***	(3.09)***
Degree	5.134	3.276	4.509	4.725	5.587
	(1.65)	(1.06)	(1.47)*	(1.52)*	(1.80)**
Up-pop		-1.177			
		(4.50)***			
Up-pop ×distance			-1.732		
			(4.65)***		
Up-pop ×bargaining				-0.565	-1.129
power × distance				(2.43)**	(2.77)***
Constant	-62.418	-16.358	-7.252	-17.693	-6.065
	(1.27)	(0.33)	(0.15)	(0.34)	(0.11)
LR		19.95***	21.32 ***	5.88 **	7.62 ***
Mean WTP	75.99	75.99	75.99	75.99	75.99
KR CI	[71.19 83.37]	[71.2 83.35]	[71.14 83.44]	[71.17 83.4]	[71.21 83.34]
Ratio	0.2	0.16	0.16	0.16	0.16

Robustness check 2 : upstream water quality replaced by the sum of weighted population of all upstream cities (DC2, Herriges and Shogren)

	Hypothesis 1	Hypothesis 2	Hypothesis 3	Hypothesis 4	
				Pop as bargain power	Growth rate as bargain power
Bid price	-0.007	-0.007	-0.007	-0.007	-0.007
	(6.58)***	(6.50)***	(6.50)***	(6.59)***	(6.49)***
rep_gov	-13.146	-13.983	-13.760	-14.992	-13.443
	(0.91)	(0.95)	(0.94)	(1.03)	(0.92)
water_problem	-2.732	-1.689	-1.050	-1.225	-1.248
	(0.20)	(0.12)	(0.08)	(0.09)	(0.09)
will_service	37.951	36.399	36.326	36.099	36.721
	(4.17)***	(4.01)***	(4.01)***	(4.04)***	(4.03)***
quality_deg	1.859	0.423	-0.940	-0.223	-1.042
	(0.14)	(0.03)	(0.07)	(0.02)	(0.08)
age	-0.182	-0.225	-0.210	-0.209	-0.218
	(0.31)	(0.38)	(0.36)	(0.36)	(0.37)
education	-1.329	-0.616	-0.546	-0.858	-0.644
	(0.70)	(0.32)	(0.28)	(0.45)	(0.33)
income_level	6.495	6.700	6.730	6.537	6.776
	(3.30)***	(3.33)***	(3.34)***	(3.32)***	(3.34)***
Income significant	26.264	28.863	29.196	27.701	29.156
higher than need	(1.62)	(1.74)*	(1.75)*	(1.70)*	(1.75)*
male	-5.577	-5.942	-6.082	-6.241	-5.755
	(0.45)	(0.47)	(0.48)	(0.50)	(0.45)
Can see the river	-11.074	-7.785	-7.653	-7.023	-7.929
	(0.49)	(0.34)	(0.34)	(0.31)	(0.35)
Far from the river	-7.295	1.256	1.895	-1.032	1.476
	(0.35)	(0.06)	(0.09)	(0.05)	(0.07)
d_fish	6.541	5.159	4.894	5.106	5.265
	(0.42)	(0.33)	(0.31)	(0.33)	(0.34)
share2nd	0.706	0.582	0.384	0.459	0.315
	(0.98)	(0.80)	(0.52)	(0.63)	(0.42)
pop_density	-0.129	0.023	0.062	-0.173	0.081
	(0.21)	(0.04)	(0.10)	(0.28)	(0.13)
gdp_growth	2.402	2.310	2.112	0.480	1.371
	(0.61)	(0.58)	(0.53)	(0.12)	(0.34)
Degree	7.122	6.091	7.070	7.908	7.263
	(1.37)	(1.16)	(1.34)	(1.50)	(1.37)
Up-pop		-4.855			
		(1.80)*			
Up-pop ×distance			-7.810		
			(1.98)**		
Up-pop ×bargaining power × distance				-7.305	-5.995
				(1.85)*	(1.79)*
Constant	-163.311	-150.277	-144.428	-120.180	-133.534
	(1.89)**	(1.73)*	(1.66)*	(1.37)	(1.52)
	0.237	0.235	0.235	0.237	0.235
Anchor Effect	(5.68)***	(5.48)***	(5.48)***	(5.66)***	(5.46)***
LR		3.551**	4.383**	3.716*	3.523*
Mean WTP	74.44	75.37	75.366	74.618	75.441
KR CI	[50.77,100.24]	[52.33,99.64]	[52.5,99.72]	[52.16,98.32]	[52.66,99.81]
Ratio	0.66	0.628	0.627	0.619	0.625

Robustness check 3 : upstream water quality replaced by number of upstream cities (MBDC, Wang and He)

	Hypothesis 1	Hypothesis 2	Hypothesis 3	Hypothesis 4	
				Pop as bargain power	Growth rate as bargain power
Bid price	-0.011 (38.13)***	-0.011 (38.13)***	-0.011 (38.13)***	-0.011 (38.13)***	-0.011 (38.13)***
rep_gov	-18.436 (2.19)**	-17.912 (2.16)**	-17.669 (2.13)**	-18.323 (2.18)**	-18.149 (2.19)**
water_problem	7.080 (0.95)	12.432 (1.68)*	11.950 (1.61)	8.423 (1.13)	12.786 (1.73)*
will_service	15.093 (3.87)***	11.499 (2.94)***	11.844 (3.03)***	13.287 (3.37)***	11.319 (2.91)***
quality_deg	20.245 (2.67)***	16.514 (2.20)**	16.596 (2.21)**	20.356 (2.70)***	15.976 (2.14)**
age	-0.271 (0.79)	-0.255 (0.76)	-0.269 (0.80)	-0.279 (0.82)	-0.276 (0.82)
education	-0.554 (0.46)	-0.433 (0.36)	-0.406 (0.34)	-0.780 (0.65)	-0.265 (0.22)
income_level	4.019 (3.96)***	4.503 (4.48)***	4.565 (4.53)***	4.171 (4.12)***	4.766 (4.73)***
Income significant higher than need	27.176 (2.96)***	27.268 (3.02)***	26.538 (2.94)***	27.701 (3.03)***	26.389 (2.93)***
male	-5.829 (0.81)	-6.344 (0.89)	-6.381 (0.89)	-6.505 (0.90)	-7.023 (0.99)
Can see the river	-25.250 (2.02)**	-21.916 (1.77)*	-22.413 (1.81)*	-24.359 (1.95)*	-22.687 (1.84)*
Far from the river	-28.295 (2.38)**	-23.241 (1.98)**	-24.003 (2.04)**	-27.554 (2.32)**	-24.280 (2.07)**
d_fish	10.770 (1.20)	13.263 (1.50)	13.488 (1.52)	11.493 (1.29)	14.670 (1.66)*
share2nd	-0.917 (2.29)**	-1.303 (3.24)***	-1.477 (3.58)***	-1.142 (2.80)***	-1.697 (4.03)***
pop_density	-1.011 (2.83)***	-0.728 (2.04)**	-0.720 (2.01)**	-1.016 (2.85)***	-0.644 (1.80)*
gdp_growth	9.605 (4.16)***	9.641 (4.24)***	9.140 (4.01)***	7.776 (3.23)***	7.913 (3.45)***
Degree	5.134 (1.65)*	3.462 (1.12)	4.646 (1.51)	5.641 (1.81)*	4.909 (1.60)
Up-nb-cities		-6.757 (4.87)***			
Up-nb-cities ×distance			-9.108 (4.66)***		
Up-nb-cities×bargaining power × distance				-5.500 (2.55)**	-8.561 (5.16)***
Constant	-62.418 (1.27)	-23.962 (0.49)	-17.051 (0.35)	-13.616 (0.26)	8.396 (0.17)
LR		23.30***	21.37***	6.45***	26.20***
Mean WTP	75.99	75.99	75.99	75.99	75.99
KR CI	[68.89 83.48]	[69.62 82.872]	[69.62 82.88]	[71.14 83.44]	[71.21 83.34]
Ratio	0.19	0.17	0.17	0.16	0.16

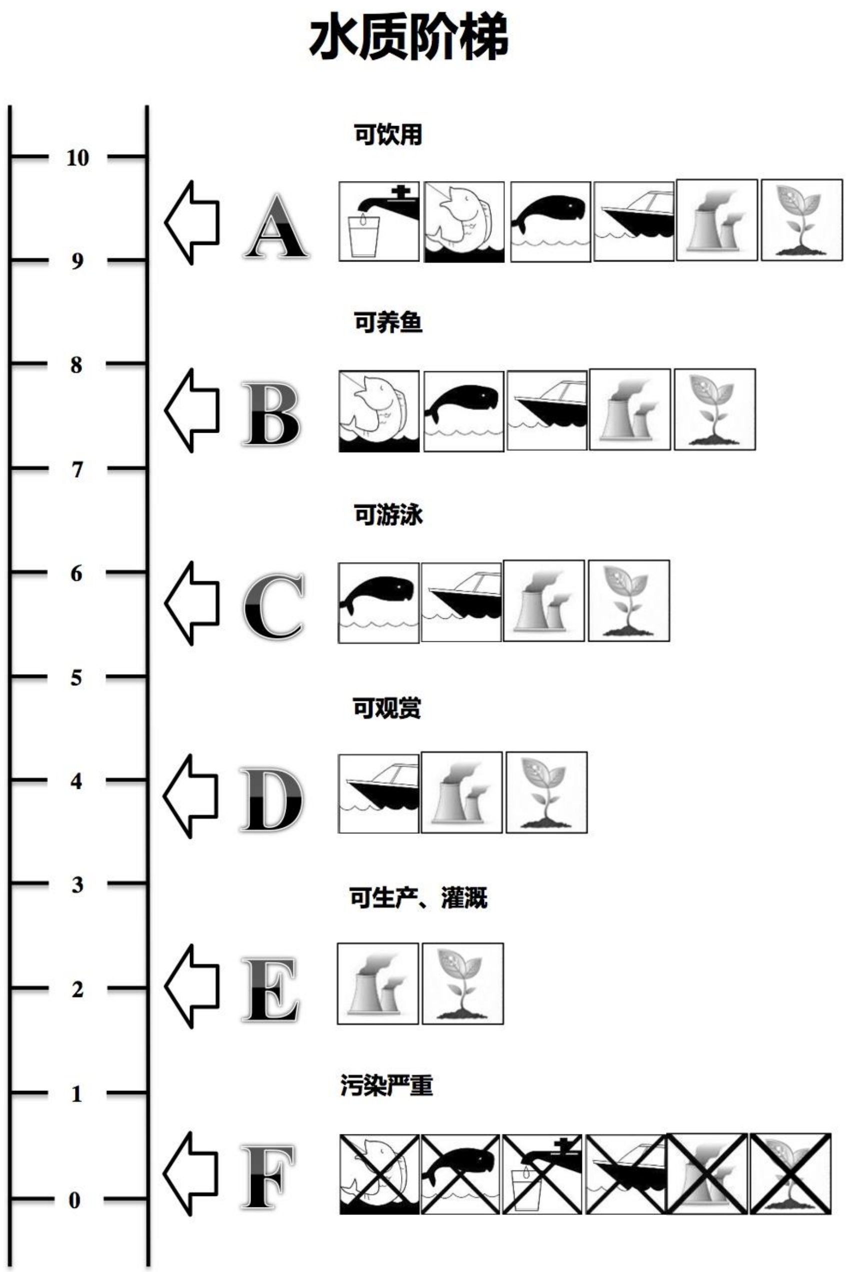
Robustness check 3 : upstream water quality replaced by number of upstream cities (DC2, Herriges and Shogren)

	Hypothesis 1	Hypothesis 2	Hypothesis 3	Hypothesis 4	
				Pop as bargain power	Growth rate as bargain power
Bid price	-0.007	-0.007	-0.007	-0.007	-0.007
	(6.58)***	(6.53)***	(6.50)***	(6.59)***	(6.49)***
rep_gov	-13.146	-13.807	-13.517	-14.877	-13.471
	(0.91)	(0.95)	(0.92)	(1.02)	(0.92)
water_problem	-2.732	-2.088	-1.226	-2.114	-1.489
	(0.20)	(0.15)	(0.09)	(0.16)	(0.11)
will_service	37.951	36.731	36.488	36.311	36.787
	(4.17)***	(4.04)***	(4.02)***	(4.04)***	(4.03)***
quality_deg	1.859	0.996	-0.526	0.246	-0.864
	(0.14)	(0.08)	(0.04)	(0.02)	(0.06)
age	-0.182	-0.220	-0.214	-0.215	-0.220
	(0.31)	(0.37)	(0.36)	(0.37)	(0.37)
education	-1.329	-0.787	-0.597	-0.897	-0.676
	(0.70)	(0.41)	(0.31)	(0.47)	(0.35)
income_level	6.495	6.643	6.723	6.550	6.760
	(3.30)***	(3.32)***	(3.33)***	(3.33)***	(3.34)***
Income significant	26.264	28.065	28.911	27.079	28.852
higher than need	(1.62)*	(1.70)**	(1.74)**	(1.66)**	(1.73)**
male	-5.577	-5.851	-6.038	-6.175	-5.773
	(0.45)	(0.46)	(0.48)	(0.49)	(0.46)
Can see the river	-11.074	-8.605	-7.728	-7.811	-8.247
	(0.49)	(0.38)	(0.34)	(0.35)	(0.36)
Far from the river	-7.295	-1.353	1.310	-2.640	0.502
	(0.35)	(0.06)	(0.06)	(0.13)	(0.02)
d_fish	6.541	5.635	5.158	5.334	5.439
	(0.42)	(0.36)	(0.33)	(0.35)	(0.35)
share2nd	0.706	0.644	0.414	0.540	0.360
	(0.98)	(0.88)	(0.56)	(0.74)	(0.48)
pop_density	-0.129	-0.064	0.011	-0.223	0.020
	(0.21)	(0.10)	(0.02)	(0.36)	(0.03)
gdp_growth	2.402	1.959	1.641	0.789	1.334
	(0.61)	(0.49)	(0.41)	(0.19)	(0.33)
Degree	7.122	6.283	7.015	7.704	7.188
	(1.37)	(1.19)	(1.33)	(1.47)	(1.36)
Up-nb-cities		-0.649			
		(1.31)			
Up-nb-cities ×distance			-1.338		
			(1.79)*		
Up-nb-cities×bargaining power × distance				-1.062	-1.032
				(1.45)	(1.64)
Constant	-163.311	-148.812	-139.434	-127.134	-133.933
	(1.89)*	(1.71)*	(1.60)	(1.44)	(1.52)
	0.237	0.236	0.235	0.237	0.235
Anchor Effect	(5.68)***	(5.54)***	(5.49)***	(5.68)***	(5.48)***
LR		1.797	3.512**	2.207*	2.918**
Mean WTP	74.44	75.087	75.327	74.538	75.366
KR CI	[50.77,100.24]	[52.19,99.14]	[52.49,99.66]	[52.05,98.17]	[52.6,99.73]
Ratio	0.66	0.625	0.626	0.619	0.625

Table ?. Mean and total WTP of cities along the main tributary of Xijiang (CNY per month)

Location of the cities on main tributary (1=most upstream, 9=most downstream)		Mean WTP (Yuan)				Aggregate WTP (Million Yuan/month)				Popolation (million)
		Wang and He, MBDC		Herriges and Shogren, DC2		Wang and He, MBDC		Herriges and Shogren, DC2		
		BAU	ΔWTP under intergarte regime	BAU	ΔWTP under intergarte regime	BAU	ΔWTP under intergarte regime	BAU	ΔWTP under intergarte regime	
1	Qujing	61.5	0	112.3	0	393.6	0	718.72	0	6.4
1	Yuxi	45.1	0	119	0	103.73	0	273.7	0	2.3
2	Qianxinan	136.4	+6.2	58.4	+10.5	381.92	+17.36	192.92	+29.4	2.8
2	Guigang	78.1	+10.6	57.7	+11	296.78	+40.28	261.06	+41.8	3.8
3	Wuzhou	70	+8.9	45.6	+7.6	203	+25.81	154.28	+22.04	2.9
4	Yunfu	20.5	+23.9	73.6	+11.4	49.2	+57.36	204	+27.36	2.4
5	Zhaoqing	75.1	+21.1	46	+8.4	292.89	+82.29	212.16	+32.76	3.9
6	Foshan	64.9	+13.9	65.5	+5.9	467.28	+100.08	514.08	+42.48	7.2
7	Zhongshan	63.6	+57.3	67.2	+9.2	807.72	+727.71	970.28	+116.84	12.7
8	Guangzhou	29.3	+16.6	85.9	+17.9	90.83	+51.46	321.78	+55.49	3.1
9	Zhuhai	36.3	+18.8	64.9	+6.2	58.08	+30.08	113.76	+9.92	1.6
Mean/Aggregate		64.1	+23.0	80.2	+7.7	3145.03	+1132.43	3936.74	+378.09	49.1

Annex 1 Water Quality Table used in the survey



Annex 2. Detailed data source for River water pollution

Data Source	Cities	Data Description
1. The weekly report of automatic water quality testing system for main rivers of China	Guigang City, Wuzhou City, Guangzhou City, Zhongshan City, Nanning City, Guiyang City, Kunming City	Transferring from Weekly Average to Monthly Average
2. Environmental Information system of the environmental protection bureau of Guangdong Province	Shenzhen City, Gongduan City, Yunfu City, Zhaoqing City， Zhuhai City, Foshan City	Monthly Average
3. Monthly report for the water quality of the main rivers in Guizhou province.	Qiannan City, Qianxinan City, Guiyang City,	Monthly Average
4. Monthly report for the water quality of the main rivers in Guangxi province.	Baise City, Liuzhou City	Monthly Average
5. Monthly environmental quality reportof the main rivers in Yunnan province.	Qujing City, Yuxi City,	Monthly Average

Annex 3. Random Valuation Model : Two-stage approche (Wang and He, 2011)

Wang and He (2011) approach implicitly assumes, as Wang (1997), that each person to have an individual WTP distribution instead of an explicit WTP value. When the proposed bid price is higher (lower) enough with respect to the WTP mean of a person's individual WTP distribution, he/she will be more certain to give negative (positive) responses, such as "definitively no" or "definitively yes". When the proposed bid price is quite close to the WTP mean, the respondent, having more uncertainty about whether to accept or not the bid, therefore may give uncertain responses ranging from "probability yes", "not sure" to "probability no".

Based on the idea of individual WTP distribution, The approach of Wang and He (2011) explicitly assumes that an individual i's WTP is V_i, which is a random variable with a cumulative distribution function F(t). The mean value of V_i is μ_i, which means the mean inidividual WTP and the standard variance is $\sigma_{i,}$ which can be considered as a measure of individual uncertainty, so higher $\sigma_{i,}$ more uncertain the individual i is. The WTP model can be written as follows:

$$V_i=\mu_i+\varepsilon_i \qquad (1)$$

Where ε_i is a random term with a mean of zero. Individual i knows his valuation distribution. When given a price t_{ij}, where the subscription j means the jth bid level given in the MBDC matrix, the probability of the individual i choosing "yes" to the offered t_{ij} will be:

$$P_{ij} = Prob(Vi>t_{ij}) =1-F(t_{ij}) + \lambda i \qquad (2)$$

where λ_i is an error term with a mean of 0 and a standard variance of δ^2. δ can be constant for a respondent i, but different for different respondents. Wang and He (2011) propose to interpret the polynomial certainty responses as probabilities P_{ij} for an individual i to accept the bid i. For example, definitively yes can be considered as the probability to accept the bid very close to one and definitively not can be considered as the probability very close to zero, etc. Once P_{ij} is known to a researcher, in our case, by assigning numerical values to the verbal MBDC data, we can estimate equation (2) for each individual i.

If a specific functional form for $F_i(\bullet)$, such as with a normal distribution, with a mean μ_i and a standard variance σ_i, i.e., $F(t_{ij}) = \Phi(\frac{t_{ij}-\mu_i}{\sigma_i})$ is assumed, then the model (2) becomes,

$$P_{ij} = 1-\Phi(\frac{t_{ij}-\mu_i}{\sigma_i}) + \lambda_i \qquad (3)$$

The primary purpose of this model is to estimate individual value for μ_i and σ_i. Then in a second step, we can further analyse the determinants of personal WTP μ_i in a simple model estimated by Ordinary Least Square (OLS).

This approach should be carried out in two steps.

First-step: Estimate equation (3) for each individual i

Assume λ_i has a normal distribution. Then,

$$\frac{P_{ij}-1+\Phi(\frac{t_{ij}-\mu_i}{\sigma_i})}{\delta} \sim N(0, 1).$$

The log-likelihood function used for estimation is:

$$\log L_i = \sum_{j=1}^{j=J} \phi\left(\frac{P_{ij}-1+\Phi(\frac{t_{ij}-\mu_i}{\sigma_i})}{\delta}\right) \qquad (4)$$

where $\phi(.)$ is a standard normal distribution probability density function. This function is equivalent to a least squares nonlinear estimation; δ has no influence on the estimation, as long as the distribution is normal. With the log-likelihood function (4), μ_i and σ_i can be estimated one by one for each individual i.

Second-step: Analyze determinants of μ_i and σ_i

Once μ_i are estimated for each individual, models can be constructed and estimated to analyze their determinants. In our paper, we will use a simple log-linear function form as following.

$$Ln(\mu_i) = \beta 0 + xi'\beta + e_i \qquad (5)$$

where the variables included in the vector xi are personal specific variables, such as personal characteristics. β signifies coefficients to be estimated; e represents random.

Annex 4: A Starting Point Bias Model of Herriges and Shogren (1996)

Let a respondent's prior willingness to pay for a given program be W_i Yuan. W_i is determined by his/her social-economics characteristics(x_i) and many other unobserved characteristics(ϵ_i) In a mathematical way, we have

$$W_i = f(x_i; \theta, \epsilon_i)$$

where θ refers to the un-estimated parameters vector of x_i and ϵ_i follow a certain distribution with zero mean value..

In the case of dichotomous choice CV, a respondent's willingness to pay can not be observed directly. But its relative location to a given bid can be known from the his/her choice. The purpose of follow-up questioning is to further narrow the possible interval on willingness to pay.

The problem with this approach is that it ignores the potential anchoring effect of the first bid offer on the subject's response to the follow-up question. If it exist, the estimated willingness to pay is biased. Herriges and Shogren (1996) model it in a simple way:

$$\widetilde{W}_i = (1-\gamma)W_i + \gamma b_{i1}$$

where W_i is a respondent's prior willingness to pay for a given product, b_{i1} is his or her first given bid and $\widetilde{W}_i$ is the revised WTP that respondent use it to help to respond to follow-up question:

$$Response = \begin{cases} Yes & \widetilde{W}_i \geq b_{i2} \\ No & \widetilde{W}_i < b_{i2} \end{cases}$$

we can rewrite it as:

$$Response = \begin{cases} Yes & W_i \geq \dfrac{b_{i2} - \gamma b_{i1}}{1-\gamma} \\ No & W_i < \dfrac{b_{i2} - \gamma b_{i1}}{1-\gamma} \end{cases}$$

if $f(x_i; \theta, \epsilon_i)$ is a liner function, $\epsilon_i \sim N(0, \sigma^2)$, the probability of saying yes to follow-up question can be written as :

$$Prob(Yes) = P\left(W_i \geq \frac{b_{i2} - \gamma b_{i1}}{1-\gamma}\right) = P\left(x_i'\theta + \epsilon_i \geq \frac{b_{i2} - \gamma b_{i1}}{1-\gamma}\right)$$

$$= P\left(\epsilon_i \geq \frac{b_{i2} - \gamma b_{i1}}{1-\gamma} - x_i'\theta\right) = 1 - \Phi\left(\frac{\frac{b_{i2} - \gamma b_{i1}}{1-\gamma} - x_i'\theta}{\sigma}\right)$$

and the probability of saying no is:

$$Prob(No) = \Phi\left(\frac{\frac{b_{i2} - \gamma b_{i1}}{1-\gamma} - x_i'\theta}{\sigma}\right)$$

we can use maximum log likelihood method to estimate the parameters, log likelihood function is:

$$logL = \sum\left(Prob(Yes) * I + Prob(No) * (1-I)\right)$$

where I is a dummy variable which equals 1 if respondent says yes to follow-up question otherwise it equals to 0.

Annex 5: Descriptive statistics

Varibles	Description	MBDC		DC2	
		mean	sd	mean	sd
1. Individual level variables					
Environmental perception					
Eco_imp	Economics development is more important than Environmental protection(0=no,1=yes)	0.60	0.49	0.59	0.49
rep_gov	Government should take the responsibility in environmental protection(0=no,1=yes)	0.73	0.44	0.72	0.45
water_problem	Water pollution is very serious in this region (0=no,1=yes)	0.60	0.49	0.67	0.47
will_service	Willingness to services for environmental protection program:5=definitely yes,4=probably yes,3=not sure,2=probably not,1=definitely no	3.90	0.94	3.93	0.99
quality_imp	quality of xijiang improved in the last three years	0.23	0.42	0.23	0.42
quality_deg	quality of xijiang degraded in the last three years	0.36	0.48	0.43	0.50
confidence	Confidence of quality impovement:4=Fully achieved,3=have a high probability of being achieved,2=probably cannot be achieved,1= cannot be achieved	2.19	1.09	2.06	1.06
Socio-economics factors					
income_willchange	Income changing with water quality improvement:5=Increasing greatly,4=Increasing,3=no change,2=decreasing,1=Decreasing greatly	2.68	1.33	2.73	1.32
age	age	34.09	10.94	34.64	11.03
edu	0=no,6=primary school,9=middle school,12=high school,16=college,19=graduate school+	14.56	3.13	13.73	3.53
income_level	Income, the income level has been subsituted with the local average wages of staff and workers(1000 Yuan)	4.44	4.10	4.71	4.87
mdaily_2	Respondents' income can only meet the needs of food(1=yes,0=no)	0.07	0.26	0.08	0.26
mdaily_3	Respondents' income can can cover the basic neccesity?(1=yes,0=no)	0.62	0.48	0.62	0.49
mdaily_4	Respondents' income can meet the needs of their daily life?(1=yes,0=no)	0.25	0.43	0.23	0.42
gender	Dummy for Male(0=female,1=male)	0.51	0.50	0.52	0.50
d_add2	Near the river but cannot see it directly	0.32	0.47	0.31	0.46
d_add3	Far away from the river	0.57	0.50	0.58	0.49
d_fish	The frequency of eating freshwater fishes (1=a least once a month,0=other wise)	0.79	0.41	0.77	0.42
2. City level macro-variables					
share2nd_mean	The share of secondary sector in gross regional output	48.15	9.51	48.62	9.44
pop_density	Population density of sampled city	17.53	13.10	16.19	12.97
gdp_growth_mean	Gdp growth rate of sampled city	14.06	1.62	14.02	1.67
3. Spatial related variables					
degree	The level of water quality	3.80	1.51	3.73	1.57
degree_upper	The level of water quality of the upper stream city	2.17	1.86	2.00	1.86
stage	A variable that record how many cities locate a city's upstream	2.57	2.71	2.35	2.63
distance	Distance between sample city and its upper stream city	1.06	1.64	1.04	1.62
pop_vs	The comparison of population between sampled city and its upstream city, which measured as Population of upstream city/Population of sampled city	0.53	0.71	0.53	0.76
gdpgwru_vs	The comparison of gdp growth rate between sampled city and its upstream city, which measured as gdp growth rate of upstream city/ gdp growth rate of sampled city	0.68	0.54	0.63	0.54
Ind_output	Aggregate industrial output of all upstream cities (weithed by distance) Variable 1 for Robustness check	83.58	146.89	67.59	131.26
Stage	Number of cities in the upstream part of the river: Variable 2 for Robustness check	2.57	2.71	2.35	2.63
N		727		910	

All of the individual level variables were directly obtained from the survey. The city-level economic and structural characteristics were compiled by the authors based on data from the China Urban Statistics Yearbook for 2011. The city-level spatial variables were calculated by the authors according to geographical information. The water pollution data were colletec from several sources, and the details of this method are provided in Annex 3.