Payment for Ecological Services and River Transboundary Pollution: Policy Inspirations from a Contingent Valuation (CV) Study on the Xijiang River Drainage Basin in South China

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Abstract

Based on the contingent valuation study results reported by He, Huang, and Xu (2015a), we propose a new payment standard-setting framework that could include the total transfer that a city should pay as a polluter or receive as a victim. This new framework differs from the previous mechanism by explicitly excluding the willingness to pay (WTP) reduction due to a city's own pollution discharge and focusing only on the WTP variation caused by transboundary pollution. This new framework also allows the calculation of detailed bilateral monetary transfers between cities depending on their location on a river and their contribution to the variation of water quality. One advantage of our approach is the possibility to identify not only polluters and victims but also "cleaners" who inherit bad water quality from the upstream neighbor and clean it up. The compensation regime proposed by our approach can thus determine both the compensation for negative externalities to be paid by the polluters to victims and the compensation from the "victim-to-be" to the cleaners for their efforts, which creates positive externalities and prevents their downstream neighbors from suffering from potential welfare loss. Based on our results, it seems that simply using the total WTP as the compensation standard for a better ecological service risks mixing the pollution caused by upstream cities with the pollution from a city's own activities, which thus tends to exaggerate the necessary compensation payment; for the Xijiang River, such exaggeration can range from 2 to 10 times. We also compared our results with the Xin'an River PES pilot program, whose transfer amount was arbitrarily fixed at 500 million yuan per year, which is approximately 86% of the compensation amount that Foshan city needs to pay to Zhongshan city. Our results therefore can be considered a supportive ar-

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gument for the general belief that the transfers currently used in the existing pilot programs are relatively low and may discourage the motivation of the cities along rivers to give sufficient effort to ecological service preservation.

Keywords: Payment for Ecological Services, payment standard, transboundary river pollution, willingness to pay (WTP), China

Pago por servicios ecológicos y contaminación fluvial transfronteriza: inspiraciones políticas de un estudio de valoración contingente (QA) en la cuenca de drenaje del río Xijiang en el sur de China

Resumen

Sobre la base de los resultados del estudio de valoración contingente informados por He, Huang y Xu (2015a), proponemos un nuevo marco de establecimiento de estándares de pago que podría incluir la transferencia total que una ciudad debe pagar como contaminador o recibir como víctima. Este nuevo marco difiere del mecanismo anterior al excluir explícitamente la reducción de la disposición a pagar (WTP, por sus siglas en inglés) debida a la descarga de contaminación de una ciudad y centrarse solo en la variación de WTP causada por la contaminación transfronteriza. Este nuevo marco también permite el cálculo de transferencias monetarias bilaterales detalladas entre ciudades en función de su ubicación en un río y su contribución a la variación de la calidad del agua. Una de las ventajas de nuestro enfoque es la posibilidad de identificar no solo a los contaminadores y las víctimas, sino también a los "limpiadores" que heredan y limpian la mala calidad del agua del vecino que está aguas arriba. El régimen de compensación propuesto por nuestro enfoque puede determinar tanto la compensación por las externalidades negativas que deben ser pagadas por los contaminadores a las víctimas como la indemnización de la "futura víctima" a los limpiadores por sus esfuerzos, lo que crea externalidades positivas e impide que sus vecinos aguas abajo sufran de una posible pérdida de bienestar. Según nuestros resultados, parece que el simple uso de la WTP total como el estándar de compensación para un mejor servicio ecológico corre el riesgo de mezclar la contaminación causada por las ciudades río arriba con la contaminación de las actividades propias de la ciudad, lo que tiende a exagerar el pago de la compensación necesaria; para el río Xijiang, tal exageración puede variar de 2 a 10 veces. También comparamos nuestros resultados con el programa piloto Xin'an River PES, cuyo monto de transferencia se fijó arbitrariamente en 500 millones de yuanes por año, que es aproximadamente el 86% del monto de compensación que la ciudad de Foshan debe pagar a la ciudad de Zhongshan. Por lo tanto, nuestros resultados pueden considerarse un argumento de apoyo para la creencia general de que las transferencias actualmente utilizadas en los programas piloto existentes son relativamente bajas y pueden desalentar la motivación de las ciudades a lo largo de los ríos para hacer un esfuerzo suficiente para preservar el servicio ecológico.

Palabras clave: pago por servicios ecológicos, pago estándar, contaminación fluvial transfronteriza, disposición a pagar (WTP), China

生态服务付费与河流跨界污染：关于中国南方西江流域意愿调查研究的政策启示

摘要

根据何、黄、许(2015a)三位学者报告的意愿调查研究结果，笔者提出了一种新的支付标准制定框架。该框架可以涵盖一个城市作为污染者应支付或作为受害者应得到的全部转移费用。这一新框架与以前的机制不同，它明确排除了由于城市自身的污染排放而导致的支付意愿(WTP)减少，而只侧重于跨界污染造成的支付意愿变化。这一新框架还允许计算城市之间的详细双边货币转移，具体取决于城市所在的流域及其对水质变化的贡献。这种方法的一个优点在于，它不仅可以识别污染者和受害者，还可以识别“清洁工”，他们从上游邻市那里继承了劣质的水源，并将其清理干净。因此，笔者所提出的赔偿制度，既可以决定污染者向受害人支付的负外部性补偿，也可以决定“准受害者”向清洁工支付的努力补偿，因为它创造了积极的外部环境，并防止下游邻市遭受潜在的福利净损失。基于笔者的研究结果，单纯以总意愿

支付原则作为更好生态服务的补偿标准，可能会将上游城市所造成的污染与该城市自身活动产生的污染混为一谈。因此，这往往会夸大所需的赔偿金；对于西江流域来说，这种夸张程度可达2至10倍。笔者还将其结果与新安江PES试点项目的结果进行了对比，该项目的转移金额随意定为每年5亿元，这大约是佛山市向中山市支付赔偿金的86%。人们普遍认为，目前在现有试点项目中使用的资金转移相对较少，可能会抑制沿江城市想要努力促进生态服务保护的动机。笔者的结果为这一看法提供了有力论证。

关键词：生态服务付费，支付标准，跨界河流污染，支付意愿原则(WTP)，中国

1. Introduction

River flows create upstream and downstream regions. However, administrative boundaries between regions do not prevent pollution in the water from crossing regional borders. Such difficulties in clearly defining the property rights of the river water flowing through different administration jurisdictions because of the weak excludability and strong rivalry of the water resources (in both terms of quality and quantity) can lead to the non-satisfaction of the basic Samuelson rules (1954). Therefore, an upstream region that is not able to enjoy the full benefits of its water conservation and pollution control efforts may exert insufficient control, which results in the overuse of water resources and the increased discharge of pollution.

Most large-scale river basins in China (e.g., the Yangtze River, Yellow River, and Xining River) span several regional jurisdictions (provinces, regions and cities). Although environmental policy is often centrally developed and local jurisdictions can only set their own environmental standards to more stringent levels than those of the national level, implementation responsibilities are devolved to the branch offices of the Ministry of Environment Protection (MEP), which operate at the provincial, municipal and county levels (Hills and Roberts 2001). Combining these two facts, we believe that there is the possibility of a problem of transboundary river water pollution for China's rivers.

Further supportive arguments for such a possibility can be made by considering the complexities and fragmentation in water resource management between the different authorities in China. Yu (2011) has described 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 environmental pollution disputes. Either overlaps or gaps that exist between the competences of the two authorities may largely compromise the efficiency of their efforts with respect to transboundary river water pollution control.

In addition to leading to higher pollution levels in neighbor regions, a more worrying aspect of transboundary pollution is its potential dynamic impacts on the motivation for regions to efficiently control their own resource usage and pollution discharge. Oates and Portney (2003) indicated that the presence of the risks of transboundary negative externalities may lead to a “race to the bottom” of regional pollution control policies since the concerns about the transboundary movements of pollution from neighbors may compromise the determination of a region to exert effective pollution control measures.

Since 2000, the payment for ecological services (PES) mechanism has become one of the most advocated environmental policy measures in China. From the beginning, many Chinese scholars have considered this policy tool to be one of most efficient measures to improve the ecological conditions of different river drainage basins and to ease the heavy pressure on China’s relatively poor water resources from economic activities. Numerous pilot projects have been carried out in China for several years. These include not only the application of the PES mechanism in wetland protection projects in many key areas but also some quantity preservation and quality improvement projects in surface waterbodies (e.g., the Beijing Miyun Reservoir, Dongjiang Source Area, Thousand Island Lake Basin, Pearl River Drainage basin and the River Heihe Drainage Basin) (MEP 2013).

Fundamentally, PES is a mechanism aiming at remedying market failures caused by the nature of public good and the poorly defined property rights of ecological services. By intentionally establishing an artificial market mechanism, the logic of the PES is to motivate and institutionalize a payment system between upstream and downstream jurisdictions along a river, which can serve as a monetary counterpart to internalize the negative externalities along rivers due to transboundary pollution over-discharge.

Although the theoretical foundation of the PES mechanism seems easy to understand, its application in the real world has proven to be much more difficult. PES is a mechanism for internalizing transboundary negative externalities; determining whether and how to apply the PES mechanism requires a good understanding of the phenomena of such externalities. Although the existence of transboundary pollution has already been confirmed at both the international and province/state levels, to date, there have been few studies that directly consider its existence in China. Additionally, even if we can provide evidence about the existence of transboundary pollution along rivers in China, to build a direct measurement of such a negative externality requires explicit identification of the source and the impact of the negative externality. Moreover, to directly relate such impact measurements to an efficient payment mechanism also requires a precise understanding of how and to what extend such a negative externality affects the well-being of people living in the downstream and upstream jurisdictions. In other words, only when a reasonable measurement of the intrinsic value of the environmental/ecological service affected by the negative externality is obtained can one have confidence to hope that the payment mechanism based on such measurement can function correctly and be incentive-compatible.

In this paper, based on the related literature collected in China and in the world, and particularly the findings from the recent contingent valuation method (CVM) study conducted by He, Huang, and Xu (2015a), we try to answer the following questions. First, what is the current situation of transboundary river water pollution problem in China? Second, if it exists, how does the transboundary pollution problem affect people's perception about the efficiency of the existing water quantity and quality control policies, whose implementation is often closely related to the local government's capacity and local economic conditions? How can such concerns affect people's expected utility improvement for a targeted better water condition? Finally, how can we establish a valid payment standard for ecological services between upstream and downstream cities, and how will be this standard compare with those of other existing studies that have analyzed similar measurements?

2. Existence of Transboundary Pollution

There is already evidence for the existence of transboundary pollution at the international level and in foreign countries. However, we have not yet found studies that directly revealed transboundary river water pollution cases based on data from China's rivers.

Based on the data of GEMS/Water[1] biochemical oxygen demand (BOD) measured by 291 river monitoring stations in 49 countries during 1979–1990, Sigman (2002) found the BOD indicator to be significantly higher at stations that were located upstream of borders than comparable stations, at least among stations located in non-European Union (EU) countries.

Because most US federal environmental policies assign regulation, implementation and enforcement responsibilities to state-level authorities, Sigman (2005) investigated potential transboundary spillover phenomena in the US. To do so, a composite water pollution index based on five major pollutants compiled from 618 monitoring stations from 1973 to 1995 was used. Using a difference-in-difference logic, Sigman (2005) found that, all else being equal, the water quality indexes were 4% worse at stations located downstream from a state authorized and with power to implement and enforce its own regulations over river water pollution.

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

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 near a river's exit from a jurisdiction. Their results confirmed that within a 5-kilometer distance from a boundary, pollution increased by 2.3% for every kilometer closer a river was to the exit border.

In addition to the river transboundary pollution cases, transboundary air pollution has been studied. One interesting example is Helland and Whitford (2003). Motivated by anecdotal evidence suggesting that local regulators were more lenient in their treatment of polluters when the incidence of pollution partially fell on those outside the state, this paper examined a transboundary air pollution spillover incidence that occurred in the US and revealed significantly higher toxic chemical levels in border counties.

3. Standards for Payment of Ecological Services

For the PES mechanism, the most important question is how to set reasonable payment standards for the affected ecological services. By "selling" the ecological services provided by environment protectors to the beneficiaries, this mechanism aims to generate funds to increase the conservation benefits perceived by the environmental protectors and therefore reinforces their incentives to protect the environment and resources. Following this logic, we should expect the payment of the PES mechanism to be higher than or at least equal to the conversation cost and/or the opportunity cost of the existing commercial development projects to which the environmental protectors face. The larger the gap is between the perceived benefit and the cost, the more room there is for negotiation between environmental service providers and beneficiaries and the higher the probability is to bring welfare increases for both sides and to realize effective environmental protection.

However, the difficulties in assigning pertinent monetary values to affected ecological services are numerous. Although natural environments represent one of the cornerstones of the human environment and offer essential goods and services for human survival and well-being, their integration into the economic system has proven to be very complex. The process to include the total economic value of nature in a neoclassical logic requires the encounter of two fundamental elements: the physical, biotic and abiotic components of nature on the one hand and the individual's view of these elements on the other. If it is reasonable to use the well-being that the individual obtains from these natural components, two aspects of the difficulty of putting a dollar value to such wellbeing remain: First, not all the wellbeing obtained by an individual is exchangeable in a market. The response of the nature to the multitude of human needs, whether aesthetic, cultural or educational, are very often non-excludable and non-rival, which means that their exchange on the market is impossible. Second, many aspects of the wellbeing that an individual receives from nature are not measurable, and some elements of the total value of nature to humans may not even be observable. A good example is the non-use value of the environment and resources: simply knowing the "existence" of good functions of the ecological system and the assurance of their provision to future generations can create satisfaction that is not associated with any observable consumption behaviors.

Previous studies have proven that the non-use value may occupy a high percentage in the total value of the environment. Wattage and Mardle (2008) found that the proportion of aggregated preferences related to the use value to conserve a wetland ecosystem was 55.3%, compared with 44.7% for the non-use value. Sander, Walsh, and Loomis (1990) concluded that the use values (e.g., irrigation, swimming, fishing, and tourism) of the 15 rivers in the state of Colorado in the United States were only approximately 1/5 of their total value; the other 4/5 of the value was principally non-use value.

We can distinguish five categories of ecological goods and service (EGS) valuation methods. The first consists of the methods that are based on market prices; they only assess the direct use value of EGS referenced to their market value. The second category consists of the methods based on costs, which estimate the EGS value by the cost of avoided damage or the replacement cost of ecosystem losses. The third category consists of the revealed preference methods (e.g., hedonic price, travel costs), which are based on consumer preferences that are revealed by their behavior in an existing market. An example of this method, the hedonic price, considers the complementarity between air quality within an area and house prices (Bateman et al. 2011; Desaigues and Point 1993; Malër 1974) and uses the increase of the house value due to the better air quality as an assessment of the economic value of the better air quality, all else being equal. The fourth category consists of methods based on stated preference (e.g., contingent valuation, discrete choice experiments), which measure the value of EGS via simulated markets to identify survey respondent trade-offs between the price to pay (or compensation to accept) and improvement (or degradation) of the environment. Finally, the benefit transfer methods involve estimating the value of EGS for a target site using existing valuation estimates from primary studies for similar sites that explicitly use one of the four preceding method categories (Navrud and Ready 2007).

Each method has its advantages and disadvantages. The measure of cost/market price is relatively easy to use but only focuses on marketable characteristics of the ecosystem. Revealed preference methods depend on observable consumer behaviors in markets for complementary goods and can thus only measure the direct- and indirect-use values of EGS. Benefit transfer is a secondary method that extrapolates the results obtained by one or many primary studies; it is thus not suitable for a primary study focusing on a specific test area. Compared with the abovementioned methods, the stated preference methods provide a more flexible approach and aim at establishing a hypothetical market framework; therefore, it can include in its assessment both the use value and the non-use value of EGS. However, stated preference methods also face criticisms that are related to their hypothetical nature (e.g., Carson and Groves (2007); Harrison and Rutström 2008; List and Gallet 2001; Murphy et al. 2005) and its potential influence on collected answers from respondents, which may lead to either an over- or under-estimation of people's WTP.

Our review of the related literature provided us with a quite interesting picture about the academic efforts in evaluating such welfare benefits. Over the last several decades, many Chinese scholars conducted interesting case studies with the aim of stimulating discussion about how to set PES payment standards. Some of them employed diverse methods based on market prices or opportunity cost, such as Cai, Lu, and Song (2008), who calculated the total engineering cost of the construction project for the water source protection area in the eastern route of the South-to-North Water Transfer Project and proposed a cost-sharing plan between regions based on the potential added-value of the ecological service improvement that they would receive. Li et al. (2009) estimated the opportunity cost of the forest protection project on the mountainous regions of Hainan and proposed to determine the payment standard based on the land holdings of different regions. Shen et al. (2009) estimated the potential loss of agricultural production due to the Green Agricultural Demonstration Project on Chongming Island. We also found several papers that calculated the loss of economic development opportunities due to water conservation projects in some river drainage basins, such as Fu, Ruan, and Zhang (2011) for the Yongding river, Zhang (2011) for the Xijiang river and Shi et al. (2012) for the Dongjiang river. Other authors chose to evaluate the potential value of the conserved ecological services; for example, Xu et al. (2006) calculated the ecological service value of the Lianhua Reservoir ecological protection project, Huang, Luo, and Yang (2008) estimated the ecological service value of the Dayao Mountain's water conservation project, Jin and Wang (2008) evaluated the use and non-use value of ecological services provided by the water conservation forest on Qilian Mountain and Cai et al. (2010) estimated the ecological service value of the wetlands in the Qilihai natural protection areas.

However, is proposing some numbers better than having no numbers? One common difficulty that those studies faced was the big divergence between the numbers they proposed. Some of these differences can be explained by the differences in the methodologies used. For example, the methods based on the opportunity cost may only include the use value of the ecological services in their estimates, whereas the stated preference methods have the capacity to include the non-observable non-use values, which may represent a large percentage of the total value of the interested ecological services. A good example is the significance coefficients that He et al. (2015b) reported for the methodological dummies in their meta-analysis estimation function, which revealed the very large impact of methodological choices on the reported value of the ecological services provided by wetlands.

It is relatively easy to accept the fact that the different evaluation methods propose relatively different valuation results for ecological services. There is another potential reason to explain the differences that has not yet gained enough attention in the literature: the ambiguity among the state preference valuation studies about "what" to evaluate.

Consider the example of a typical payment scenario for ecological services related to a better water quality provided by an upstream region. Ideally, the downstream residents, as the beneficiaries of the improved ecological services provided by the better quality of river water flowing from the upstream regions, should only pay for the part of the increase in ecological services directly related to the better water quality contributed by the upstream regions. Such logic is already well reflected in the mechanism of some pilot PES projects, such as the trans-provincial project on the Xin'an River (2012–2014). This project required that the decision to transfer a proposed 500 million yuan between the upstream Anhui province and the downstream Zhejiang province be based on the water quality of the river section located in the congruent frontier between the two provinces. If the water quality meets the required class II level, the 500 million yuan will be transferred from Zhejiang to Anhui to compensate for their water pollution abatement efforts. Conversely, if the water quality does not meet the required level, the transfer will go from Anhui to Zhejiang province to compensate for the additional damage caused by the worse water quality. Whether to make a transfer depends on whether the Xin'an River water received by Zhejiang from Anhui meets the required quality target. Compared with this specificity, the welfare changes that many existing stated preference valuation studies measured unfortunately were wider; most of them focused on the potential reduction of local people's well-being due to the changes in the quality of the local ecological service. For the case of river water pollution, the local water quality changes certainly "inherit" the pollution flows from the upstream regions but are also directly affected by the injection of pollution from local economic activities and everyday life.

4. A New Framework for Setting Payment Standards with the Stated Preference Methods

Considering the above discussion, we use the following Figure 1 to illustrate the different sources of pollution in a transboundary river. Assuming that the river water at the starting point S has a quality equal to or better than level II, the river flows from the point S (start) to point E (end) and goes through five regions (A, B, C, D and F). All five regions discharge pollution into the river and thus can be considered polluters. They also suffer from the concentration of the pollution in the section of the river flowing through their jurisdictions and can thus be considered as victims. However, it is important to distinguish between the simple victims of river water pollution and the victims of the transboundary pollution; only the latter can be qualified for the discussion about payment ecological service compensation. Region A is located at the starting point of the river and does not have upstream neighbors. Therefore, although A is the polluter of the river and victim of the pollution in the river due to its own pollution discharge, it is not a transboundary pollution victim. Taking now the case of region B, since A is its upstream neighbor, it is possible for B to be a transboundary pollution victim. However, to confirm the victim role of region B, another condition is that the quality of the river water received by region B from region A is worse than Class II, the targeted river water quality. The same discussion can be applied to regions C and D. Finally, for region F, since it is located at the end point of the river, F can only be a transboundary victim but not a transboundary polluter since the river water, after flowing through the region F, will flow into the ocean and thus does not affect other populations living in the drainage basin.

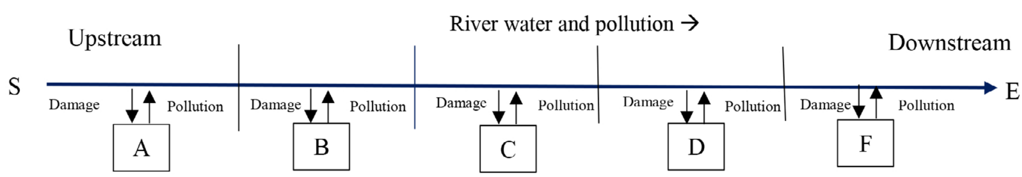

Figure 1. Polluter and Victim in a Transboundary Pollution Case

Once the conditions to identify transboundary pollution-related polluters and victims are clear, another related question is about when and how the PES is installed. There are two possible situations. First, although all regions discharge pollution into the river, if the water quality collected at all transboundary sections of the river between regions stays at a constant class II level, it will not be necessary to apply a PES mechanism because each region manages to keep the water quality as clean as the water they receive from their upstream neighbors; therefore, we can consider the situation as not having transboundary pollution between regions (Figure 2).

However, the situation can be much more complicated if the information about the water quality in the transboundary section of the river is organized as in Figure 3. The identification of the polluter and victim of transboundary pollution needs to con-

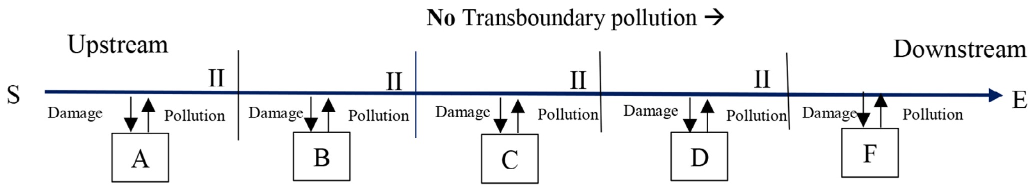

Figure 2. No PES Transfer Regime When There Is No Transboundary Pollution

sider the quality of the water that a region receives from its upstream neighbor and the quality of the water that it leaves to its downstream neighbor. For example, if region A, which keeps the water quality on its border with B at the required Class II level, should not be considered a transboundary polluter, then B will not be considered a transboundary victim. However, if the water quality between B and C is found to be at class III after flowing through region B, this means that B is unable to guarantee the same water quality as that received from A. In such a case, B will be regarded as a transboundary polluter and should be responsible for the damage suffered by the population living in all three downstream regions (C, D and F; the green arrows illustrate the direction of the compensation from B to the three downstream regions). A possibility for region C illustrated in the figure is that C manages to keep the water quality at level III, which is lower than the required quality but is equal to the quality of the water it receives from B; therefore, we should not consider C a transboundary polluter but simply a transboundary pollution victim (caused by B). If region D receives class III water quality but leaves its water quality even worse at class IV, D should be considered both a transboundary polluter responsible for the damage caused in region F (the blue arrow illustrates the compensation from D to F) and a transboundary pollution victim of region B.

In Figure 4, we present another possible spatial distribution pattern of transboundary water pollution. Compared with Figure 3, in this new scen-

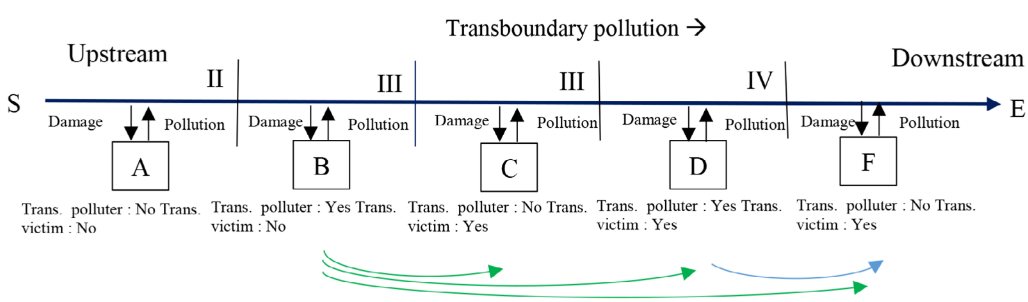

Figure 3. PES Transfer Regime with Transboundary Pollution: Scenario 1

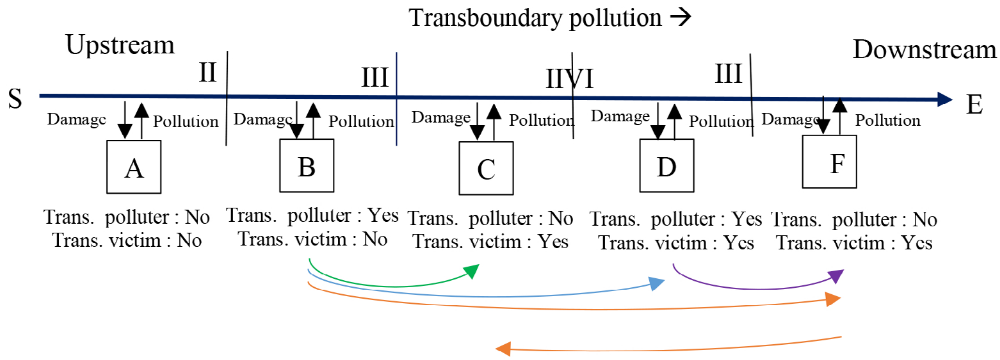

Figure 4. PES Transfer Regime with Transboundary Pollution: Scenario 2

ario, we assume that region C exerts more than necessary efforts and thus brings the water quality back to Class II level, which means a quality better than what it received from its upstream neighbor B. In such a situation, since C helps D and F avoid the negative externality from the Class III level polluted water, C should be eligible to recuperate the compensation paid by B to D and F (illustrated by the arrows of the same color but in opposite directions).

Based on this logic, if we conduct a state preference study among these cities with the aim of providing a standard for PES, simply questioning people's WTP for the water quality improvement target to Class II level cannot give us the correct information about the necessary amounts of payment transfers between cities because the water quality in the section of river flow through one particular city depends not only on the pollution discharged by the city itself but also on the pollution flows from the upstream cities.

We can use a WTP function to illustrate this idea for the case of the five cities A, B, C, D and F over the river. The WTP for each of the five cities can be written as

$$W_A = w\left(\overset{+}{\overbrace{Q_A}}\right) \tag{1}$$

$$W_B = w(\overset{+}{\overbrace{Q_B}}, \overbrace{Q_{AB} - II}^{-}) \tag{2}$$

$$W_C = w\left(\overbrace{Q_C}^{+}, \overbrace{Q_{BC} - II}^{-}\right) = \left(\overbrace{Q_C}^{+}, \overbrace{(Q_{BC} - Q_{AB}) + (Q_{AB} - II)}^{-}\right) \tag{3}$$

$$W_D = w\left(\overbrace{Q_D}^{+}, \overbrace{Q_{CD} - II}^{-}\right) = w\left(\overbrace{Q_D}^{+}, \overbrace{(Q_{CD} - Q_{BC}) + (Q_{BC} - Q_{AB}) + (Q_{AB} - II)}^{-}\right) \tag{4}$$

$$W_F = w\left(\overbrace{Q_F}^{+}, \overbrace{Q_{DF} - II}^{-}\right) = w\left(\overbrace{Q_F}^{+}, \overbrace{(Q_{DF} - Q_{CD}) + (Q_{CD} - Q_{BC}) + (Q_{BC} - Q_{AB}) + (Q_{AB} - II)}^{-}\right) \tag{5}$$

Here, we assume that the WTP of the respondent living in a city i, W_i, depends not only on the water quality situation of the section of the river flowing through the city, Q_i, but also on whether the quality of the transboundary section of the river with its upstream neighbors is better or worse than the targeted level Class II. In general, we believe a worse quality of the water (signifying a higher Q_i motivates a higher WTP of the population in city i for the achievement of the water quality improvement target; therefore, we expect a positive relationship between Q_i and W_i. This WTP for a better water quality target is also negatively affected by the existence of negative externality caused by transboundary water pollution because a worse transboundary pollution level signifies more difficulties in realizing the targeted water quality improvement. We therefore expect a negative relationship between W_i and the water quality of the transboundary section of city i with its upstream neighbor i−1, $Q_{i-1,i}$, when $Q_{i-1,i}$ is found to be worse than Class II level. Because this reduction of the WTP of people living in city i is directly related to the transboundary pollution caused by upstream city i−1, we propose to use this part of the WTP reduction as a valid base to set the payment standard for the PES mechanism.

To distinguish the related PES transfers between cities, we further decompose the transboundary pollution-related responsibility among the cities, which corresponds to the last part of the equations to the right of the last equal sign. Simple manipulation provides an interesting responsibility sharing regime among cities according to the water quality of the transboundary sections between them. Take the spatial transboundary pollution allocation pattern given in Figure 4 as an example:

City A is not a transboundary pollution victim since it is located at the beginning part of the river; this is also revealed in its WTP determination function $W_A=w(Q_A)$, which does not include a WTP reduction term related to the transboundary section pollution level.

For city B, as its upstream city A maintains Q_{AB}=II, the reduction of the WTP of city B due to transboundary pollution is equal to zero, which means a zero transfer from A to B.

For city C, because its transboundary section pollution with B is at class III, higher than that between A and B at class II, we have $Q_{BC}-Q_{AB}>0$, and C should receive a compensation from city B whose amount equals the reduction of WTP, which is $-W_D(Q_{BC}-Q_{AB})$. However, city C should not be compensated by city A since A keeps the water quality to the targeted Class II level, therefore $W_D(Q_{AB}$-II$)=0$.

The situation of city D is that its upstream neighbor city C manages to restore the water quality in the transboundary section back to class II (Q_{C-D}=II)from class III (Q_{BC}=III). Therefore, city C does not need to compensate city D. However, this does not mean that there is no money transfer between city C and city D, which can be seen from the decomposition part of the equation, where Q_{CD}-II is further decomposed into three parts: $(Q_{AB}-Q_{BC})<0$, $(Q_{CD}-Q_{BC})<0$, $(Q_{BC}-Q_{AB})>0$ and $(Q_{AB}$-II$)=0$. Associating these terms with the negative correlation factors of w_D, we know that $w_D(Q_{CD}-Q_{BC})>0$, which signifies an increase of the welfare of people in city D because of the water quality improvement efforts of city C. This motivates a transfer from D to C equal to $w_D(Q_{CD}-Q_{BC})>0$. We also have $w_D(Q_{BC}-Q_{AB})<0$, which means a transfer to receive by D from B. Since Q_{CD}=II and Q_{AB}=II, we have $(Q_{CD}-Q_{BC})=-(Q_{BC}-Q_{AB})$; therefore,$W_D(Q_{CD}-Q_{BC})=W_D(Q_{BC}-Q_{AB})$, which signifies that the transfer from D to C for welfare increase is equal to the transfer from B to D as compensation for welfare decrease. Therefore, the transfer from B to D is simply used by D to compensate C for its abatement efforts. An intuitive way to interpret such double-transfers is that the "polluter" city B compensates the "cleaner" city C for its effort that prevents the negative externality of city B's transboundary pollution from affecting city D.

Finally, for city F, since Q_{DF}=III, which means that city D creates transboundary pollution to F, $W_F(Q_{DF}$-III)>0 However, the total WTP changes can also be decomposed into four parts: $(Q_{DF}-Q_{CD})>0$, $(Q_{CD}-Q_{BC})<0$, $(Q_{BC}-Q_{AB})>0$, $(Q_{AB}$-II)=0 and $(Q_{CD}-Q_{BC})=-(Q_{BC}-Q_{AB})$. Therefore, we can distinguish a compensation transfer from D to F, as $W_F(Q_{DF}-Q_{CD})<0$, and a compensation transfer from B to F, as $W_F(Q_{BC}-Q_{AB})<0$. The latter part is then transferred to the cleaner part, the city C, as $W_F(Q_{CD}-Q_{BC})=-W_F(Q_{BC}-Q_{AB})>0$. 5. Application of the New PES Standard Setting Regime using He, Huang, and Xu (2015a)

5. Application of the New PES Standard Setting Regime using He, Huang, and Xu (2015a)

This new PES payment standard setting regime implies an important fact: the payments between upstream and downstream cities should be based not on the current pollution situation of river sections across the cities but on that of the transboundary section flowing between the cities. This requires the stated preference studies to include both information types in the estimation of WTP, which thus makes it possible to isolate the part of the WTP variation in one city due to the transboundary pollution coming from its neighbors.

Among the numerous stated preference valuation studies that aimed to provide a payment standard for river related ecological services, we have been able to identify only one paper that directly studied the influence of the transboundary water pollution on the WTP of people in China, that of He, Huang, and Xu (2015a), which is based on an in-person CVM survey conducted in 2012 in the 20 cities of four provinces (Guizhou, Yunnan, Guangxi and Guangdong) of southern China belonging to the Xijiang river basin.

The Xijiang River is the main channel and longest tributary of the Pearl River (cf. Figure 5). The Xijiang River flows for 2,217 kilometers from the north of Yunnan province eastward across Guizhou province and Guangxi province and through the Pearl River delta in Guangdong province and final-

Figure 5. Xijiang River Drainage Basin with 20 Surveyed Cities
(the size of the circle signifies the population of the surveyed city)

ly terminates at the southern China Sea near Macau; it is the largest river system in southern China. Similar to other regions in China, the Xijiang River Basin has experienced trends of increasing inequality with respect to economic development over the last 35 years. Uneven development between regions naturally leads to considerably different interpretations by regional governments about 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 and cities, several western inland regions are still willing to endorse environmental damage in the interest of attracting investment in productive but polluting sectors. He, Huang, and Xu (2015a) expected the uneven economic growth levels between regions along the Xijiang River to exacerbate the transboundary pollution problem because the poor inland provinces, located upstream from the Xijiang river basin, remain willing to sacrifice the environment for growth. These inland provinces are also rich in nonferrous metal reserves, whose extraction practices highly pollute water resources.

Before the WTP questions, the survey first provided the respondents with a general description of the current water quality for the 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 Xijiang 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."

Then, the current water quality of the section of the Xijiang River flowing through the city where a respondent lived was presented with the help of the water quality ladder inspired by Mitchell and Carson (1989) and adapted to the water quality standard used in China. The river basin-level uniform water quality improvement target proposed by our hypothetical project is fixed at the swimmable level (C level on the water quality ladder illustrated in Figure 6), which corresponds to level II of the Chinese Ministry of Environment Protection classification. The respondents were then asked if they were willing to pay a monthly payment for the realization of this water quality improvement.

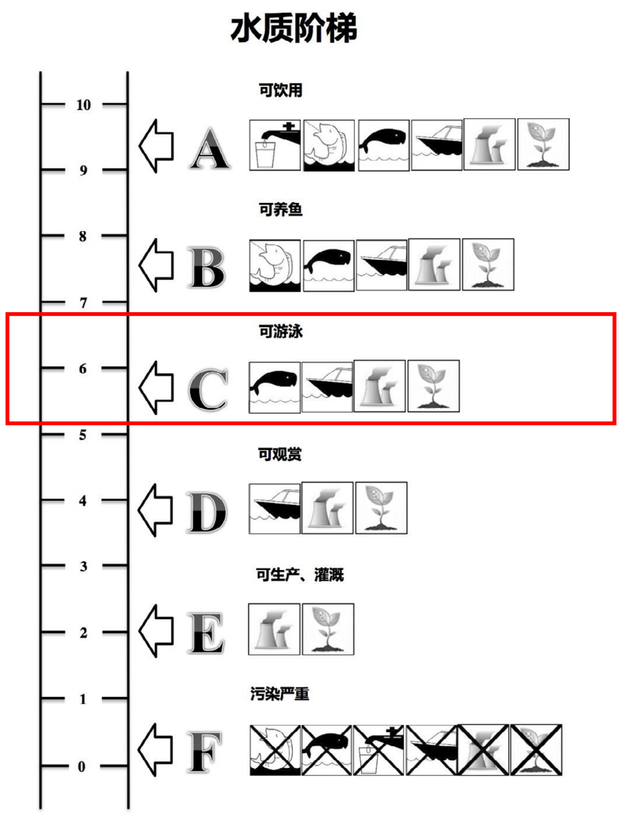

Figure 6. Water Quality Ladders

Stratified random sampling was used 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 (cf. Table 1). The recruited samples generally show relatively good gender balance but a higher concentration of younger and more educated people in our sample compared with the general population (cf. Table 2).

Table 1. Sample Details for Each City

City	Population[2] (Million)	Sample Size[1]
Guangzhou	12.7	110
Shenzhen	10.4	90
Dongguan	8.2	71
Fuoshan	7.2	35
Guiling	7	55
Nanning	6.7	31
Kunming	6.4	48
Qujing	5.9	33
Guiyang	4.3	30
Guigang	4.1	11
Zhaoqing	3.9	35
Liuzhou	3.8	35
Baise	3.5	20
Qiannan	3.2	30
Zhongshan	3.1	11
Wuzhou	2.9	18
Qianxinan	2.8	23
Yunfu	2.4	15
Yuxi	2.3	11
Zhuhai	1.6	15
Total	**102.4**	**727**

[1]After the data cleaning. [2]Data source: Statistics book of sixth national population census of the People's Republic of China. The database illustrated here is the sub-sample (about the half of the total sample) of the survey using the Multiple-Bound Discret Choice format WTP question. The other part of the data that we did not use in this paper is based on a dichotomous choice format WTP question.

Table 2. Statistic Descriptives of the Respondents

Variables	Definition	Mean	S.D.
Age	Years	34.09	10.94
Years of education	Years	14.56	3.13
Income level	Income (1,000 Yuan/month)	4.44	4.1
Income higher than need	Respondents' income can meet the needs of their daily life? (1=yes,0=no)	0.25	0.43
Male	Dummy for male (0=female,1=male)	0.51	0.5

The database illustrated here is the sub-sample (about the half of the total sample) of the survey using the Multiple-Bound Discret Choice format WTP question. The other part of the data that we did not use in this paper is based on a dichotomous choice format WTP question.

In Table 3 we reproduced the part of the estimation results of He, Huang, and Xu (2015a) based on the subsample using the MBDC (Multiple Bound Discrete Choice, Wang and He 2011; Welsh and Poe 1998) format WTP questions.[2] The last two estimation functions (hypotheses 2 and 3) illustrated in Table 1 used both individual- and city-level characteristics to explain the monthly WTP. The key variables of our interest are those included in the section called water quality-related variables, where both the water quality of the river flowing through the city of a respondent's residence (degree) and the water quality of the section of river flowing through the direct upstream cities (degree_upper) were included in the explanation of monthly WTP. As can be seen from the estimation called "hypothesis 2", the monthly WTP of a respondent was positively and significantly affected by the water quality of the river crossing his/her resident cities but was negatively related to the water quality of the direct upstream city. The LR test reported at the bottom of Table 1 compared the model, including the variables of the water quality of the direct upstream city, with that excluding such variables. Including the water quality of the upstream cities significantly increased the explanative power of the estimation models and thus supported the relevance of including those variables.

However, the results associated with the variable degree_upper in the model called "hypothesis 2" do not exactly correspond to the new framework that we proposed. This is because the upstream city's water quality was used as the determinant of WTP, not the exact information of the water quality at

2 The other half split questionnaires used the double-bound dichotomous choice (DBDC) elicitation strategies, whose results illustrated obvious bias related to the starting price anchor effect.

the transboundary section of the river. We therefore believe that it is better to use the estimation result of model "hypothesis 3" to establish the payment standard since the cross-term used in this model, degree_upper×, can be considered a proxy for the water quality in the section of the river flowing through the boundary between city j and its direct upstream neighbor k, where is the distance between city k and its direct upstream neighbor j along the river. This term implies the notion of "distance decay" of the river water pollution concentration because of the auto-purification capacity of the river; that is, the further the city j is from its upstream neighbor k, the more the auto-purification function of the river can help to reduce the concentration of the pollution in the section of the river flowing into the city k. Therefore, the further city k is from city j, the lower will be the impact of its transboundary pollution on city j. Our choice was supported by the LR test, which confirmed that the use of the cross-term degree_upper× gave significantly better estimation results than the simple term degree_upper and by the improved statistical significance of the coefficients for the upstream water quality related term.

Table 3. Main Estimation Results of He, Huang, and Xu (2015), MBDC Version Data

	Hypothesis 1	**Hypothesis 2**	**Hypothesis 3**
Individual characteristics			
Bid price	—0.011	—0.011	—0.011
	(38.13)***	(38.13)***	(38.13)***
rep_gov	—18.436	—18.666	—18.159
	(2.19)**	(2.22)**	(2.17)**
water_problem	7.080	9.700	10.930
	(0.95)	(1.29)	(1.46)
will_service	15.093	13.791	13.203
	(3.87)***	(3.51)***	(3.37)***
quality_deg	20.245	20.217	18.151
	(2.67)***	(2.68)***	(2.41)**
age	—0.271	—0.177	—0.178
	(0.79)	(0.51)	(0.52)
	—0.554	—0.614	—0.534
education	(0.46)	(0.51)	(0.44)
income_level	4.019	3.825	3.988
	(3.96)***	(3.76)***	(3.95)***

Income significant higher than need	27.176	27.677	27.058
	(2.96)***	(3.03)***	(2.97)***
male	—5.829	—5.859	—5.975
	(0.81)	(0.81)	(0.83)
Can see the river	——25.250	—24.755	—24.015
	(2.02)**	(1.98)**	(1.93)*
Far from the river	—28.295	—28.315	—27.186
	(2.38)**	(2.39)**	(2.30)**
d_fish	10.770	9.815	9.611
	(1.20)	(1.10)	(1.08)
City level characteristics			
share2nd	—0.917	—1.383	—1.670
	(2.29)**	(3.06)***	(3.63)***
pop_density	—1.011	—0.580	—0.186
	(2.83)***	(1.43)	(0.43)
gdp_growth	9.605	10.790	9.831
	(4.16)***	(4.57)***	(4.29)***
Water quality related variables			
degree	5.134	5.264	5.990
	(1.65)*	(1.69)*	(1.93)*
degree_upper		—5.574	
		(2.22)**	
			—13.564
degree_upper$\times \frac{1}{1+D_{j,k}}$			(3.24)***
Constant	—62.418	—49.903	—28.804
	(1.27)	(1.01)	(0.58)
LR		4.09**	10.45***

t statistics are displayed in parentheses, The stars *, ** and *** indicate the significance level at the 15%, 10%, and 1%, respectively.

This is a part of the Table 5 published in He, Huang, and Xu (2015a, P113).

The LR test reported at the bottom of the Table 1 compares the model including the variables of the water quality of the direct upstream city with that excluding such variables.

Based on the models "hypothesis 2" and "hypothesis 3" and the new framework for PES payment standard setting, we calculated two new PES payment schemes for the nine cities located along the main stream of the Xijiang Rivers, as shown in Table 4. For a specific city j, a negative number reported in the column titled signifies a loss of the welfare of a representative person of its population due to the transboundary pollution flowing from its upstream neighbor j−1. Therefore, we could use this number to time the population size of the city j to obtain its total welfare loss caused by the pollution from its upstream city j−1. To remedy such welfare loss, the amount that the upstream city k needs to transfer to city j should be equal to the absolute value of this product, as illustrated in the last two columns of Table 1.

Additionally, in Table 5, we report the detailed bilateral transfers between cities according to their geographical location and the water quality situations in the transboundary sections between cities. The numbers proposed in the table were calculated according to equations (1) to (5). The upper panel of the table was based on the model "hypothesis 2", and the lower panel was based on the model "Hypothesis 3". A positive number signifies a transfer from city k (upstream) to city j (downstream) to remedy the negative externality caused by k to j, whereas a negative number means a transfer from city j (downstream) to city k (upstream) for the improvement of the water quality and, thus, a positive externality.

There are several interesting and logical findings from the comparison between the results based on models "hypothesis 2" and "hypothesis 3". For example, the "distance decay" nature of river water pollution can significantly reduce the compensation burden for the upstream polluters. Additionally, for a city located a very small distance along the river from its very-populous direct downstream neighbor, even a small amount of transboundary pollution signifies a large amount of compensation. In both cases, the distance plays a very important role in the determination of the compensation amount.

6. Discussion and Conclusion

The new payment standard setting framework proposed in our paper directly concentrates measurements on the negative or positive externality caused by transboundary water pollution. This is very different from most of the previously mentioned preference studies, which focused on measuring the impacts of isolated and hypothetical quality changes in ecological services on people's welfare that were rarely related to the transboundary pollution context.

Based on the paper of He, Huang, and Xu (2015a), our new payment standard setting framework can propose both the total transfers that a city should make as a polluter or receive as a victim. This new framework also allows the calculation of the detailed bilateral monetary transfer between cities, depending on their location on the river and their contribution to the variation of water quality. One advantage of our approach is the possibility to not only

Table 4. The Loss of Welfare due to Transboundary Water Pollution and the Total Transfer to Remedy Such Negative Externality

Location of the city j on main tributary (1=most upstream, 9=most downstream) *in the bracket (water quality, population in million)					Individual mean WTP (Yuan)			Total transfer (|ΔWTP|×population, million Yuan) from city j–1 to j	
j	City j	Water quality	Population (million)	Distance to upstream neighbor (km)	WTP reported in He et al. (2015a)	$\Delta WTP = W_j(Q_k - II)$, k: direct upstream neighbor	$\Delta WTP = W_j\left(\frac{Q_k - II}{1 + D_{j,k}/100}\right)$, k: direct upstream neighbor	Based on model “hypothesis 2”, where $\Delta WTP = W_j(Q_k - II)$	Based on model “hypothesis 3”, where $\Delta WTP = W_j\left(\frac{Q_k - II}{1 + D_{j,k}/100}\right)$
1	Qujing	IV	6.4	—	61.5	—	—	—	—
2	Guigang	II	3.8	268	78.1	−10.15	−7.37	38.57	28.01
3	Wuzhou	III	2.9	261	70	0	0	0	0
4	Yunfu	III	2.4	100.2	20.5	−5.57	−6.78	13.37	16.27
5	Zhaoqing	II	3.9	67.9	75.1	−5.57	−8.08	21.72	31.52
6	Foshan	IV	7.2	81.12	64.9	0	0	0	0
7	Zhongshan	II	3.1	133	29.3	−10.15	−11.64	31.47	36.08
8	Guangzhou	IV	12.7	31.69	63.6	0	0	0	0
9	Zhuhai	IV	1.6	38.6	36.3	−10.15	−19.57	16.24	31.32

Table 5. The Details of the Bilateral Transfer Between Cities

Based on model "hypothesis 2"						Cities k								
City j	$\Delta WTP = W_j(Q_k - II)$, k: direct upstream neighbor	Water quality	Population (million)	Distance to upstream neighbor (km)	Total transfer received	PES transfer matrix $W_{j,k}$ (positive values means transfer from city k (upstream) to city j (downstream), negative values means transfer from city j (downstream) to city k (upstream)on the line to city in the column)								
						Qujing	Guigang	Wuzhou	Yunfu	Zhaoqing	Foshan	Zhongshan	Guangzhou	Zhuhai
Qujing	—	IV	6.4	—		—	—	—	—	—	—	—	—	—
Guigang	−10.15	II	3.8	268	38.57	38.57	—	—	—	—	—	—	—	—
Wuzhou	0	III	2.9	261	0	29.44	−29.44	—	—	—	—	—	—	—
Yunfu	−5.57	III	2.4	100.2	13.37	24.36	−24.36	13.37	—	—	—	—	—	—
Zhaoqing	−5.57	II	3.9	67.9	21.72	39.59	−39.59	21.72	0	—	—	—	—	—
Foshan	0	IV	7.2	81.12	0	73.08	−73.08	40.10	0	−40.10	—	—	—	—
Zhongshan	−10.15	II	3.1	133	31.47	31.47	−31.47	17.27	0	−17.27	31.47	—	—	—
Guangzhou	0	IV	12.7	31.69	0	128.91	−128.91	70.74	0	−70.74	128.91	−128.91	—	—
Zhuhai	−10.15	IV	1.6	38.6	16.24	16.24	−16.24	8.92	0	−8.92	16.24	−16.24	16.24	—
Total payment due to the responsibility of transboundary pollution of city k						381.66	−343.09	172.12	0	−137.03	176.62	−145.15	16.24	—
Based on model "hypothesis 3"						Cities k								
City j	$\Delta WTP = W_j\left(\frac{Q_k - II}{1+\ln(D_{j,k})}\right)$, k: direct upstream neighbor	Water quality	Population (million)	Distance to upstream neighbor (km)	Total transfer received	PES transfer matrix $W_{j,k}$ (positive values means transfer from city k (upstream) to city j (downstream), negative values means transfer from city j (downstream) to city k (upstream)on the line to city in the column)								
						Qujing	Guigang	Wuzhou	Yunfu	Zhaoqing	Foshan	Zhongshan	Guangzhou	Zhuhai
Qujing	—	IV	6.4	—	—	—	—	—	—	—	—	—	—	—
Guigang	−7.37	II	3.8	268	28.01	28.01	—	—	—	—	—	—	—	—
Wuzhou	0	III	2.9	261	0	12.51	−12.51	—	—	—	—	—	—	—
Yunfu	−6.78	III	2.4	100.2	16.27	8.93	−8.93	16.27	—	—	—	—	—	—
Zhaoqing	−8.08	II	3.9	67.9	31.52	13.27	−13.27	19.73	11.79	—	—	—	—	—
Foshan	0	IV	7.2	81.12	0	22.24	−22.24	27.96	11.02	−38.98	—	—	—	—
Zhongshan	−11.64	II	3.1	133	36.09	8.31	−8.31	8.72	2.05	−10.77	36.09	—	—	—
Guangzhou	0	IV	12.7	31.69	0	33.04	−33.04	33.52	8.12	−41.64	153.33	−153.33	—	—
Zhuhai	−19.57	IV	1.6	38.6	31.32	4.01	−4.01	3.92	0.86	−4.78	14.33	−14.33	31.32	—
Total payment due to the responsibility of transboundary pollution of city k						130.32	−102.31	110.12	33.84	−96.17	203.75	−167.66	31.32	—

identify polluters and victims but also "cleaners" who inherit bad water quality from the upstream neighbor and clean it up. The compensation regime proposed in our approach can accordingly determine not only the compensation for negative externalities to be paid by the polluters to victims but also a compensation from the "victim-to-be" to the up-stream cleaners for their efforts that create positive externalities and avoid potential welfare loss. We believe such two-direction compensation systems can more efficiently discourage the creation of negative externality and encourage that of positive externality, both of which contribute to better river water quality.

It is difficult to directly compare the numbers proposed in our approach with those from previous studies. One reasonable comparison that we can make is between the compensation that we proposed in this paper and the aggregate WTP reported in He, Huang, and Xu (2015a) for the achievement of the targeted Class II level river water in corresponding cities. The latter can be regarded as an example similar to most of the previous valuation studies that have used the WTP as the compensation standard for a better ecological service quality. Referring to the three columns under the individual WTP in Table 2, we can make the general observation that using the total WTP for a better ecological service quality risks mixing up the pollution caused by the upstream cities and the pollution from a city's own activities and thus tends to exaggerate the necessary compensation payments. According to Table 5, such exaggeration ranged from 2 to 10 times for the Xijiang River. Another possible comparison is with the pilot PES project at the Xin'an River, in which the transfer between two provinces is arbitrarily fixed at 500 million Yuan per year. Taking the potential necessary transfer between Foshan and Zhongshan cities as an example, the total yearly transfer is already equal to 86% (36.09*12 months) of the total transfer between Zhejiang and Anhui provinces. Shen et al. (2015) advocated the necessity to increase the transfer amount for the Xin'an River PES pilot to reinforce the water protection motivation of both provinces; our paper can be considered as a supportive argument for their policy recommendation, although we admit the potentially big difference between the Xin'an and Xijiang Rivers.

Another advantage of the new approach for payment standard setting is to directly associate the compensation amount that a city needs to pay (for negative externality) or to receive (for positive externality) with the size of the victims/beneficiaries of the related externality. From the point of view of efficiency, for a specific city, the further it is located toward the upstream end of the river, the larger will be the size of its potential victims/beneficiaries and thus the higher will be the amount of compensation to pay or to receive if it creates negative or positive externalities. Such logic, acting with more emphasis on the more upstream cities, can largely contribute to efficiency of the control of transboundary pollution and thus facilitates the realization of the water quality improvement targets of an entire river.

From equity point of view, as most of upstream cities located in the inland China are also at the same time less developed cities, the further is the city located in the upstream end, further its river cleanup effort will be recognized and well compensated.

The numbers proposed in our study for the PES standard are certainly specific to the case of the Xijiang River. Although it is technically feasible to use the estimated coefficients from the models reported in Table 1 to extrapolate the impact of transboundary pollution on the variation of people's WTP in specific cities, such extrapolation still produces biases. These biases can come from the fact that different rivers present different bio-physical characteristics or that the cities located along a river may have particular geographical patterns and specific mutual economic relationships. Admitting that not all these specificities can be considered with the coefficients obtained from cities belonging to another river drainage basin, we welcome more high-quality stated preference studies to be conducted and used as bases for the proposal of PES payment standards. Such measures will make it possible to compare the results from different regions and river basins and thus facilitates a more practical discussion about whether it is reasonable to extrapolate the results for one drainage basin to another.

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