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Contingent Valuation Methodology: Evaluation of Benefits of Improving Water Quality in the Lake Tai Region

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Abstract

Environmental economics is a relatively new field in the subject of economics. While the developing countries are growing and developing rapidly, the conflict between economic development and environmental preservation is becoming more and more irreconcilable. This methodology paper addresses the relationship between the water quality in the Lake Tai Region in China and economic benefits, and presents the contingent valuation methdology (CVM) to evaluate benefits.

Keywords

Environmental economics, contingent valuation methdology, benefits, water quality, the Lake Tai Region, China

I. INTRODUCTION

The Lake Tai region is one of the most industrialized areas in China with a high population density and a rapidly developing economy. Centered in the area, Lake Tai has been playing a significant role in supplying water for human consumption, agricultural production, environmental production and industrial production. Thus, it is important to discover one or more solutions to evaluate problems related to pollution in the Lake Tai region.

Lake Tai is the second largest lake in China and is located in the lower delta plain of the Yangtze River, the longest river in China. With an area of 36,500 square kilometers and home to thirty-four million people, the Lake Tai region has seven large cities, which are Shanghai, Nanjing, Hangzhou, Suzhou, Wuxi, Changzhou and Huzhou. The lake provides water directly consumed by at least half of the total population there (Qin, 2008).

The Lake Tai region is called "the land of fish and rice," which reflects its enormous contribution to agricultural production. In fact, it accounts for 3% of the country's total rice production and is one of three national bases of freshwater fish and silk production (Lee, 2007). As for the environmental production, Lake Tai is home to 106 types of fish. Besides, with the diverse landscape, warm climate and vast water area, it is a wonderful habitat for many sorts of flora and fauna, which make Lake Tai a great resort and park for urban residents from cities nearby. The natural beauty of Lake Tai brings tourism and real estate business here, but they have a sensitive relationship with the lake's water quality. There were fifteen million people who traveled to Lake Tai in 2010 and the total revenue from the tourism industry of the region was fifteen billion yuan (2.35 billion dollars) (Gu, 2010). The pollution could harm local tourism by keeping people who have traveled there away from a second trip and worsening the reputation of the area's tourism (Cerina, 2008).

Furthermore, the Lake Tai region is less than 0.4% of the total area of China while producing over 14% of the total GDP in China. Therefore, being at the front line of economic development in China, the Lake Tai region has been heavily polluted. In May of 2007, a bloom of toxic cyanobacteria had turned Lake Tai fluorescent green. Toxic cyanobacteria, generally referred to as pond scum, turned the big lake into a "land of death". The stench of decay choked anyone who walked within a mile of its shores. All these cyanobacteria came from wastes of agricultural and industrial production, which had not been filtered before the disposal (Lee, 2007). These bacteria made the growth of algae boom in the lake skyrocket and caused the rapid deterioration in the lake environment. As such, at least two million people were out of clean water. Also, the blue algae boom reduced the tourism revunue of Wuxi, a big city very close to Lake Tai, to 50% of that in the previous year (Le, 2007).

The outburst of cyanobacteria and algae was not a coincidence or natural disaster caused by the lack of rain in the previous month. The Lake Tai region has

been developed and polluted for a long time. Since the 1950s, the government had constructed dams to improve irrigation and control floods, but these artificial projects destroyed the cleansing circulation of fresh water (Yimin et al, 2011). Phosphates and other pollution-borne nutrients led the lake to be eutrophic.

In 1978, Chinese authorities started to put a new proposal, called Chinese Economic Reform, into practice. Since it was a coastal area with several developed cities, the Lake Tai region was open to all factories, which were mainly chemical-oriented factories, up to 2,800. Obviously, chemical factories consumed and discharged large quantities of water. These factories had a high consumption of clean water from the lake and a great amount of disposal to the lake. Although the government was trying to attract more chemical factories which heavily polluted the environment, nobody was standing up against it because, by the mid-1990s, taxes on the chemical industry profits accounted for four-fifths of the local governments's revenue, and these factories generated a large number of jobs.

The conflict between development and pollution occured after the mid-1990s. There were no fish in creeks from Lake Tai and all these streams were black and red (Yimin et al., 2011). After 2001, Wen Jiabao, the prime minister of China came to visit Lake Tai. In 2006, both the president, Hu Jintao, and the prime minister passed the proposal that the state and local government put money, labor and technology into cleaning the Lake Tai region.

In conclusion, since the Lake Tai region is very important in human consumption, agricultural production, environmental production and industrial production, it is critical to find a way to deal with pollution efficiently. The main purpose of this paper is to identify and research the environmental good, which is the Lake Tai region, and to evaluate the environmental concern, which is the pollution in that area.

II. LITERATURE REVIEW

According to Chen and Wu (2008), fish of freshwater ecosystems have an enormous economic importance. They reported that the quantity of fish that had been caught increased at a large scale while the quality of fish decreased over decades. The annual harvest of fish increased from 10,000 tonnes in 1952 to 20,000 in 2000, doubling in almost half a century (Chen and Wu, 2008). In addition, the quality of fish has decreased in recent decades. Based on previous reports, the diversity of freshwater fish has been reduced from 106 species in the 1950s (East China Normal Unviersity, 1959) to 47 species in the 2000s (Zhu, 2004).

While the population is growing in the Lake Tai region, the demand for fish is also increasing rapidly. Nevertheless, the quality of Lake Tai as an ecosystem has deteriorated, which will decrease the production of fish. Even though nutrient enrichment has a positive effect on fishery productivity in nutrient-limited lakes (Stockner and Shortreed, 1988; Melack, 1976a; Liang et al.,

1981; Hoyer and Jones, 1983; Downing et al., 1990; Quiro•s, 1990; Gomes et al., 2002), there is sufficient evidence showing that, at a highly eutrophic level, sustainable harvests of the fish population decline (Beeton, 1969; Lee et al., 1991; Caddy, 1993). Bootsma and Hecky (1993) and Hammer et al. (1993) explained that excessive nutrients in the lake diminished the fish productivity with the reduction in the amount of food available and the quality of the habitat, such as the quality of water and sediments. Deoxygenated water boosts the natural mortality of fish and sedimentation has a negative effect on the fish eggs laid on nursery grounds. Kemp et al. (2001) indicates that high pressure from demand for fish can make the fishing industry even worse by affecting fish stock biomass and fishery yields negatively.

Besides the fishing industry, real estate business is also involved with the water quality in the Lake Tai region. A house with an area of 700 square meters (7500 square feet) on the lakeside has a price of eight million yuan (1.26 million dollars). Because China is in transition from its people living primarily in downtown to a majority in suburbs, the housing price at the lakeside is undervalued now and has a great potential to increase. However, the water quality has a huge impact on the price of houses on shores of Lake Tai. Boyle et al. (1998) find that poor water quality has a negative effect on house prices in the studies on water clarity. Hodgkinson and Valadkhani (2009) also explain that poor water quality has a negative impact on house prices. Moreover, Michael et al. (2000) demonstrate that improvements in water quality have a positive effect on property prices.

There are three ways to evaluate environmental effects of water pollution in Lake Tai according to the literature. Simonit and Perrings (2011) introduce a model to indicate the correlation between changes in land usage, wetland area, water quality and fish stock biomass in Lake Victoria, Kenya. Their model applies data from a range of closely allied systems to develop an approach to the valuation of this class of ecosystem. In the lake ecosystem, nutrient flows affect the relative abundance of a number of species of fish. The impact of nutrient loading on the water body is modeled through the effect it has on the productivity of fishing in shallow lakes. Simonit and Perrings (2011) build a bioeconomic model of the fishing industry which is closely affected by the water quality. Their model includes a damage function which depends on nutrient loading, changes in chlorophyll-a concentration - a measure of water quality and eutrophication.

Another way is the hedonic pricing methodology (HPM). Hodgkinson and Valadkhani (2009) conduct a research in community valuations of environmental quality of coastal lakes in Lake Illawarra, Australia. They imply that since the house purchase is generally considered as the most important investment decision made by Australian households, the application of HPM would be reasonable and accurate. The premium reflects the community's "willingness to pay" (WTP) for a location near the lake and, therefore, acts as an indirect valuation of the lake assets by that community (Willis, 2005). They hypothesize that the community

valuation of Lake Illawarra is considerably higher than the current actuarial values placed on it by the State Government and that this would be reflected in a premium on house prices associated with proximity to the lake. The lake value measures in their study resulted from the community reactions to recent improvements in recreational and lakeshore amenities. In the study, HPM is used to place a value on proximity to the lake, as an indirect community valuation of the lake. With HPM, they apply data collection from all single residential properties sold in the calendar year 2006 in the ten suburbs surrounding Lake Illawarra. The dependent variable is house price. The independent variables are environmental quality, location, house characteristics, financial aspects, access and neighborhood characteristics. In order to measure the environmental quality, they use the distance in meters to the nearest lakeside, a dummy variable indicating whether the house has a lake frontage and infrastructure work to improve water quality.

Since at the time of their study the data for water quality is not sufficient, they introduce another model, a repeat sales model (Bailey et al., 1963; Palmquist, 1982) to estimate benefits of environmental improvement and the value which residents place on environmental changes.

The third way is contingent valuation methodology (CVM). In Carson and Hanemann's paper (2005), they demonstrate the history, economic theory, types, elicitation formats, econometric issues, survey design and administration, and consistency of results between theoretical prediction and actual behaviors about contingent valuation methodology. Carson and Hanemann (2005) indicate that CVM asks for individuals' willingness to obtain changes to an environmental good or service, or their willingness to allow the environmental good or service to be degraded in a hypothetical setting. They explain that contingent valuation is an inherently more flexible tool than revealed preference techniques, such as hedonic pricing and the household production function approach, because it is possible to use CVM to examine environmental goods and terms for providing them that are different from what have been observed now or in the past (Carson and Hanemann, 2005).

Contingent valuation (CV) surveys have been used to value large discrete changes, for instance, the introduction of a new public good, the value associated with substituting one good for another, or the marginal value associated with changing one or more attributes of an existing good (Carson and Hanemann, 2005). CV surveys are generally organized in the following procedures which reflect current practice: (1) an introductory section identifying the sponsor and general topic, (2) a section asking questions concerning prior knowledge about the good and attitudes toward it, (3) the presentation of the CV scenario including what the project was designed to accomplish, how it would be implemented and paid for, and what will happen under the current status quo situation if the project were not implemented, (4) question(s) asking for information about the respondent's WTP/WTA for the good, (5) debriefing questions to help ascertain

how well respondents understood the scenario, and (6) demographic questions (Mitchell and Carson, 1989; Bateman et al. 2002; Carson and Hanemann, 2005).

III. METHODOLOGY

Back in the review of literature, the first two major studies researched environmental issues related to lakes and explained the economic effects of degraded water quality on the local community. They contribute to my hypothesis that improving water quality in the Lake Tai region will have a positive effect on benefits in local communities and these benefits can be a large amount of money.

In this paper, CVM is applied as the methodology to estimate the societal benefits of improving water quality (or eliminating pollution) in Lake Tai. Since the objective of the paper is to deal with the pollution in Lake Tai, finding out the societal values of changing the current situation would make it easier to determine the most effecient policy.

Since the fact that pollution is not a commodity makes determining the value of its removal difficult, asking individuals' maximum WTP to clean the lake water is the most accurate and reasonable method to estimate values. Therefore, a CVM survey is the best way to do it.

There are six steps in doing a CVM survey in the review of literature but this paper modified them into four major steps: (1) identifying the importance of eliminating pollution in the Lake Tai region and describing the benefits of improving the water quality in the whole area, (2) identifying respondents to be approached and identifying procedures, (3) designing and applying the survey questionnaire, and (4) analysis of results and aggregation to estimate benefits of changes from a heavily polluted Lake Tai to a clean and clear one for residents who live in the region.

The first part in the survey is to identify the importance and benefits of reducing pollution in the Lake Tai region. A short article will be written to explicitly explain the current situation in the Lake Tai region, which is about the serious pollution affecting the entire society negatively. It will also indicate that how critical a clear Lake Tai is to the industry, agriculture, living condition and future development and how many benefits local residents can gain from paying money to solve the environmental issues in the Lake Tai region.

It is important to keep all people who take the survey as completely informed as possible. Because there is information bias in CVM, the more the people know about the significance of dealing with the pollution in the region, the more accurate their true WTP will be. Moreover, it is important to set up a hypothetical situation to inform respondents that how many benefits local people would obtain if the Lake Tai region was cleaned up. These benefits include more jobs and revenue from the attraction of more high-technology companies and tourists. Once the interviewees are aware of the importance and benefits, their WTP would be much closer to their real WTP.

The second step is to identify respondents to be approached and procedures. This research focuses on finding the benefits based on users' perspectives. Since Carson and Groves (2007) assert that a survey question needs to meet certain conditions in which respondents answering the question need to care about what the outcomes of those actions might be, these respondents have to be users of the environmental good or service. The Lake Tai is the center of the Lake Tai region and shares borders with Jiangsu Province, Zhejiang Province and Shanghai District, so respondents are selected from local residents who live in these three states. Improving the environment of Lake Tai will have different scales of benefits to different fields, such as industry and agriculture.

However, in the paper, all these fields are generalized as one and benefits that the improvement can bring are simply considered equal. Besides, the ratio of urban area to rural is close to 1 to 1. Thus, respondents are selected among people who live in five sample cities, Shanghai, Suzhou, Wuxi, Jiaxing and Huzhou, and five sample towns in the countryside, Wujiang, Yixing, Xishan, Nanquan and Mudu. The total sampling size is 3,500, 0.1% of total population in the area with a sampling size of 1,750 for urban residents and a sampling size of 1,750 for rural residents. Mitchell and Carson (1989) explain that payments for most pure public goods were made at the household level, so the unit for each respondent is the household in the research.

The procedures to conduct surveys are mail and personal interviews. The primary reason that mail surveys are used is that they are the cheapest way to collect data. Personal interviews are applied because they would decrease information biases. Interviewers are able to explain things that respondents are not clear about in face-to-face interviews. It is also highly efficient because every personal interview can get all surveys back with complete opinions from respondents.

The third step is to design and apply the survey questionnaire. The WTP question is demonstrated as the following (Wang and He, 2010) :

> "Suppose the government is deciding to eliminate the pollution in the Lake Tai region, mainly Lake Tai. The project will be finished in three years. In three years, you will be able to get clean and clear water in the Lake Tai region and you would get all types of benefits from better living conditions, higher agricultural yields, more relocation of highly paid companies and a bright future with social and environmental sustainabilities. However, the government needs everyone to donate some money to make this project run smoothly and efficiently. We would like to know how likely you are to pay for the implementation of this project.
>
> Please note that, (1) different people have different plans for living, such as to relocate to other parts of China or other countries. Therefore, the likelihood that different people truly need the project is different. If a person won't live in the Lake Tai region in three years, he / she may not

need this project to be executed; and (2) with a given income, a person needs to buy other good and services such as food and clothes, etc.

We only want to know the likelihood that you would pay for this project, given the following list of prices, to make sure you would have all these benefits listed above in three years. There is no right or wrong answers. We really want to know how you would react to the different prices. Please select one possibility under each price given in Table 1."

Table 1

Price	**Definitely Not**	**Probably Not**	**Not Sure**	**Probably Yes**	**Definitely Yes**
None (0 yuan)					
10 yuan					
30 yuan					
50 yuan					
70 yuan					
100 yuan					
150 yuan					
200 yuan					
300 yuan					
500 yuan					
700 yuan					
1000 yuan					
1500 yuan					
2000 yuan					

Price	Definitely Not	Probably Not	Not Sure	Probably Yes	Definitely Yes
5000 yuan					

The last step is the analysis of results and aggregation to estimate benefits. The probability answer: we encode probability values as

1 = absolutely yes
0.75 = probably yes
0.5 = not sure
0.25 = probably not
0 = absolutely not

The dependent variable is each respondent's real WTP, M. The independent variables are the price, Pij and probability, U, proposed by the questionnaire. Variable i is for the number of the respondent and j is the price he is WTP at the certain probability. For a respondent i, whether or not to accept at a price Pij is dependent on his WTP distribution. Thus for each respondent, his or her WTP for the project is:

Mi = Pi0*U1 + Pi10*U2 + Pi30*U3 + Pi50*U4 + Pi70*U5 + Pi100*U6 +
Pi150*U7 + Pi200*U8 + Pi300*U9 + Pi500*U10 + Pi700*U11 +
Pi1000*U12 + Pi1500*U13 + Pi2000*U14 + Pi5000*U15
where U is among {1, 0.75, 0.5, 0.25, 0}

The real WTP is: M(3,500) = (• Mi / 3500) * 35,000,000

Comparing the real WTP and the cost of eliminating pollution in the Lake Tai region, we can estimate the societal values and benefits of doing so. With the evaluation, making and implementing a policy of dealing with the pollution in the Lake Tai region would be more efficient and economical.

IV: Conclusion

The paper addressed the methodology of CVM and provides a model for future studies. The Lake Tai region is the fastest growing region in China, and with the data gathering and empirical study from further researches, we will be able to clarify the real benefits of improving water quality in this area and present cost-efficient solutions to improve it. Moreover, environmental economics is a recenlty fast-developing category and the methodology addressed in this paper would help researchers to conduct surveys and evaluation processes of all enviromental goods in other regions.

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