Measure of Watershed Ecological Compensation Standard Based on WTP and WTA

Dawei XU*, Jinfang RONG, Na YANG, Wen ZHANG
Faculty of Management and Economics, Dalian University of Technology, Dalian 116024, China

Abstract  In this paper, Liao River Basin was taken as the research object and field surveys were conducted in Fuxedian, the source of Liao river mainstream and Panjin, the estuary of Liao River. Through the questionnaires, the willingness to pay (WTP) and willingness to accept (WTA) of the residents in Liao River Basin were analyzed. Then based on analysis of the existing ecological compensation standard measuring methods, the WTP and WTA using contingent valuation method were measured and analyzed. Without considering other factors, and based on using the nonparametric estimation method, it was concluded the ecological compensation standard of Liao River Basin was 160.72 yuan/person • years. When considering other factors, using the parametric estimation we obtain that the ecological compensation standard of Liao River Basin was 255.97 yuan/person • years. Measuring the respondents’ WTP and WTA at the same time and processing the average can actually reflect the respondents’ real WTP, thus to a certain extent solving the problems of high compensation caused by formulating ecological compensation standards according to measuring WTP of respondents separately. In addition, the policy suggestions have been proposed from three aspects including financial transfer payment, ecological compensation forms and public participation system. This will not only protect residents’ right to know and strengthen public participation and supervision, but also benefit the comprehensive implementation of ecological environment of Liao River Basin and establishment of a long-term mechanism of water resources protection.

Key words  Ecological Compensation, WTP, WTA, CVM, Liao River Basin

1 Introduction

Along with the rapid development of social economy, there is an increasing demand of water resources in people’s daily life. However, because of the attention on economic growth speed rather than the changes of water capacity and quality, there are a series of problems, such as water shortage, water quality pollution, and decrease of underground water level. In the meantime, because different regions cover different administrative areas, people in the lower reaches would have conflict with people in the upper reaches for the application and allocation of water resources, which has become practical problems to be solved soon. As a kind of institutional arrangement, eco-compensation aims at protecting ecological environment and promoting the harmony between people and nature, based on the service value of ecological system, ecological protection cost, development cost and comprehensive use of administrative and market measures. The eco-compensation system can quicken the development of upper reach and decrease regional disaster, which would promote the sustainable development of social economy in the region. However, in the theoretical study and actual practice of ecological compensation mechanism, the principle, choices of methods and models have become the key and difficulty in the academic research. Therefore, based on field survey and questionnaires, CVM was applied to study the WTP and WTA so as to explore the key to relevant theories of ecological compensation standards in China.

2 Summaries

Since the end of 1990s, some western countries have started to practice and study ecological compensation. In 1990, Germany made ecological compensation to Yibeiriversides and the entire project cost 20 million mark. Through economic compensation, Australian government tried to push forward the comprehensive management work through financial subsidy. American government adopted water and soil preservation mechanism, namely to ask people in the lower reaches offer financial compensation to people in the upper reaches who made contribution to the environment. For instance, New York city invested in the upper reaches of Catskills and built up clean water transaction. Loomis discussed the total economic value of recovering five kinds of ecological system and analyzed the relation between WTP and the social economic information variables of WTP. Amigues studied the WTP and WTA in Garonne River in France. Bienable and Hearne carried out studies on willingness and CE studies, and they built many regression models. Results indicated that different groups of people were willing to enhance payment of environment service. Mora and McVittie made questionnaires towards people’s WTP towards ecological compensation in Scotland and they found that people had strong willingness to pay in the form of income tax. Surender Kumar and Shunsuke Managi applied the optimal financial transferring theory to study the compensation mechanism that local Indian government provides to public environmental service. Ana Villarroya and Jordi Puig thought that the ecological compensation standard was far lower than the expected standards. Supported by National Natural Science Program (71273038 and 70973013); Late Period Funded Project of Philosophical and Social Science Research for the Ministry of Education (11JH0031); Liaoning Finace Science Research Project (12C004). * Corresponding author. E-mail: xudawei@dlut.edu.cn
Berdu Bahulo Balana et al. used correlation analysis method to evaluate the preference of land owners so as to provide services in Kapingazi. C. Gert Van Hecken et al. studied the PES and evaluated the WTP of lower reaches consumers. Study on the ecological compensation started from then end of 1990s. Some experts deem that since the external costs of ecological compensation has become internalized, the precision of ecological service value was considered as the core content and the ecological compensation standard was the main theoretical basis. Zhang Zhiqiang et al. studied the WTP of residents in Hehai region towards the recovery of ecological service in Zhangye region and concluded that the economic benefit of ecological service in Zhangye was above 22.462 8 million yuan. Xu Dawei et al. investigated and measured the mean willingness to pay of residents in Zhengzhou by PC. The general willingness to pay of residents in Zhengzhou was estimated. Cai Bangcheng et al. proposed the compensation standard of using ecological service outcome to share ecological compensation cost. Xu Jian et al. made various compensation plans. Li Huai’en et al. measured the ecological compensation of water resources in Shaanxi, being 8.004 6 million Yuan. Duan Jin et al. discussed the conditions to balance the supply and requirement, and had built general structure and method to calculate the direct cost of ecological compensation. Zhang Leiqin applied models and documents to study the ecological compensation standard in Anhui Quipu River based on ecological compensation service, opportunity cost and market price of water resources. Wei Chu and Shen Manhong constructed a model to measure ecological compensation standard based on quantitative economics. Li Qin et al. used CVM method to study the WTP of tourists towards Tianmu Lake through questionnaires. Li Chaoxian adopted open form to evaluate the WTP through questionnaires and values, and concluded that the mean WTP towards the treatment of ecological compensation in Xiangjiang was 70. 32/ (Month · House). Yun Xuezhong et al. proposed to use cost benefit as the accountability to compensate the evaluation method. Yan Li et al. analyzed the willingness to pay in Dongjiang region. Zhang Tao applied opportunity cost method to evaluate the water resource ecological service value in Xijiang region. Liu Qiang et al. used ecological protection cost method and conditional evaluation method study ecological compensation standard in Dongjiang.

Therefore, how to know the stakeholders’ real willingness to compensate is a difficult issue for research on ecosystem service payment. In China, the study of ecological compensation has gradually transferred from macro study to quantitative study, and the empirical study of ecosystem service value mainly applies contingent valuation method. In measuring the respondents’ WTP and WTA at the same time and processing the average can actually reflect the respondents’ real WTP, thus to a certain extent solving the problems of high compensation caused by formulating ecological compensation standards according to measuring WTP of respondents separately. In addition, the policy suggestions have been proposed from three aspects including financial transfer payment, ecological compensation forms and public participation system. This will not only protect residents’ right to know and strengthen public participation and supervision, but also benefit the comprehensive implementation of ecological environment of Liao River Basin and establishment of a long-term mechanism of water resources protection.

3 Status quo of the study region
Liao River Basin is an important economic zone in our country but it is one of the regions short of water resources and suffering from water pollution severely. Liao River locates in southwest part of China, between 116°30’ and 125°47’ E, and from 38°43’ to 45° N. The entire region covers 2. 196 billion km², from Jilin, Inner Mongolia to Liaoning. Liaohe is composed of two rivers, one of 516 km and the other of 94 km. Liao River Basin covers 69 thousand km², of which the arable land covers 19. 7 thousand km² and the forest area is 25. 6 km². However, the latest data of Environment in China suggested that among seven large rivers, Liao River was generally of heavy pollution.

4 Study methods
4.1 The method to measure the ecological compensation standard
One basis to determine the ecological compensation standard is to determine the value of regional ecological system service. Davis applied CVM for the first time in 1963 to study the value of a forest in Maine State in America. Later, lots scholars began to use CVM to calculate the environment resource value. Since the 1970s, CVM has been used to evaluate various public products and relevant policies. Currently, CVM is the only way to evaluate the value of environment and services. Contingent valuation method revealed the largest WTP to improve environment through simulated market. It is to directly inquire people about their willingness to pay for environmental-friendly products. Different from market value method, CVM is not based on market behavior, but on the answer of interviewees.

4.2 Deign of questionnaires
The questionnaire includes three parts. Firstly, the importance and significance of ecological compensation mechanism in Liao River Basin is introduced. Secondly, WTP and WTA of interviewees are concluded through questionnaires. Thirdly, the social economic information of interviewees is collected, including the age, sex, culture level and income of interviewees.

4.3 Investigation
There are 226 questionnaires in the investigation, among which 220 copies are effective. In order to ensure the effectiveness of samples, face to face form is conducted in the intersection of east and west Liao River in the last ten days of July in 2010.

5 Study result and its analysis
5.1 Statistics of interviewees’ basic information
There are 226 copies of questionnaires, among which 220 copies are effec-
5.2 Distribution of WTP of interviewees Although people in Liao River Basin has learned about ecological compensation to certain extent, most people thought it is necessary to compensate the ecological protection behavior in the upper reaches of Liao River Basin. However, interviewees' answers on who should compensate vary from each other. In order to determine the value of Liao River Basin towards the ecological service in Liao River Basin, WTA and WTP were studied together.27.

Table 1 The interviewees' social economy characteristic variables and their descriptive statistics

<table>
<thead>
<tr>
<th>Variables</th>
<th>Definition and value</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>95% credibility</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>1 = male; 2 = female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>1 = 18 – 25 years old; 2 = 26 – 35 years old; 3 = 36 – 50 years old; 4 = 51 – 60 years old; 5 = above 61 years old</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Job</td>
<td>1 = Farmers; 2 = small private business; 3 = Civil servants; 4 = Private companies; 5 = State company; 6 = Workers; 7 = Urban dwellers; 8 = Laid-off workers; 9 = Non-government workers; 10 = Others</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>1 = Primary school; 2 = Junior high; 3 = Senior high; 4 = College; 5 = University</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family income</td>
<td>1 = 5000; 2 = 5001 – 10000; 3 = 10001 – 20000; 4 = 20001 – 30000; 5 = 30001 – 40000; 6 = 40001 – 50000; 7 = 50001 – 60000; 8 = 60001 – 70000; 9 = 70001 – 80000; 10 = 80001 – 90000; 11 = 90001 – 100000; 12 = 100000</td>
<td>1.35</td>
<td>0.478 057</td>
<td>0.063 522</td>
<td>0.228 539</td>
</tr>
</tbody>
</table>

Table 2 Accumulative frequency distribution of WTP

<table>
<thead>
<tr>
<th>WTP Yuan</th>
<th>Absolute frequency</th>
<th>Relative frequency %</th>
<th>WTP Yuan</th>
<th>Absolute frequency</th>
<th>Relative frequency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>26</td>
<td>11.8</td>
<td>125</td>
<td>8</td>
<td>3.6</td>
</tr>
<tr>
<td>15</td>
<td>13</td>
<td>5.9</td>
<td>175</td>
<td>3</td>
<td>1.4</td>
</tr>
<tr>
<td>25</td>
<td>9</td>
<td>4</td>
<td>250</td>
<td>7</td>
<td>3.2</td>
</tr>
<tr>
<td>35</td>
<td>6</td>
<td>2.7</td>
<td>350</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>45</td>
<td>27</td>
<td>12.3</td>
<td>450</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>55</td>
<td>9</td>
<td>4</td>
<td>750</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>65</td>
<td>2</td>
<td>0.9</td>
<td>1250</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>75</td>
<td>7</td>
<td>3.2</td>
<td>1750</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>85</td>
<td>11</td>
<td>5</td>
<td>2500</td>
<td>4</td>
<td>1.8</td>
</tr>
<tr>
<td>95</td>
<td>33</td>
<td>15</td>
<td>178</td>
<td>80.91</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>42</td>
<td>19.09</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>220</td>
<td>100</td>
<td>178</td>
<td>80.91</td>
<td></td>
</tr>
</tbody>
</table>

5.3 Range of WTA and its distribution The estimated value of WTA in this questionnaire is as follow; if you are the victim in the lower reaches or the contributor in the upper reaches, how much would you accept as compensation?

5.4 The result is shown in Table 1.

Fig. 1 The percentage of different payment methods


The result is shown in Table 3. Among all interviewees, 78.18% residents are willing to accept ecological compensation.
Meanwhile, 21.82% are not willing to accept the compensation because they think they are not victims to the deteriorating environment or the one who contribute to environment.

The compensation form is studied and the result is shown in Fig. 2. Among all people, 44% interviewees prefer cash, while 28% and 22% chose financial subsidy or tax deductions.

6 Data analysis of WTP and WTA

6.1 Non-parameter evaluation of WTP and WTA

If relevant variables such as the basic characteristics of interviewees are not considered, the desired value of WTP and WTA were deduced:

\[
\begin{align*}
E(WTP) &= \sum p_i V_i \\
E(WTA) &= \sum p_i V_i 
\end{align*}
\]

(1)

(2)

where \( v_i \) stands for the \( i \)th value of the interviewees. \( p_i \) stands for the \( i \)th probability of interviewees. The data is shown in Table 2 and Table 3. WTP and WTA of interviewees are considered.

\[
\begin{align*}
E(WTP) &= 125.09 \text{ Yuan/People} \cdot \text{Year} \\
E(WTA) &= 196.35 \text{ Yuan/People} \cdot \text{Year}
\end{align*}
\]

Table 3 Accumulative frequency distribution of WTA

<table>
<thead>
<tr>
<th>WTA</th>
<th>Absolute frequency People</th>
<th>Relative frequency %</th>
<th>WTA</th>
<th>Absolute frequency People</th>
<th>Relative frequency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>13</td>
<td>5.9</td>
<td>125</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>15</td>
<td>9</td>
<td>4.1</td>
<td>175</td>
<td>5</td>
<td>2.3</td>
</tr>
<tr>
<td>25</td>
<td>5</td>
<td>2.3</td>
<td>250</td>
<td>8</td>
<td>3.6</td>
</tr>
<tr>
<td>35</td>
<td>2</td>
<td>0.9</td>
<td>350</td>
<td>5</td>
<td>2.3</td>
</tr>
<tr>
<td>45</td>
<td>9</td>
<td>4.1</td>
<td>450</td>
<td>6</td>
<td>2.7</td>
</tr>
<tr>
<td>55</td>
<td>11</td>
<td>5</td>
<td>750</td>
<td>5</td>
<td>2.3</td>
</tr>
<tr>
<td>65</td>
<td>3</td>
<td>1.4</td>
<td>1250</td>
<td>6</td>
<td>2.7</td>
</tr>
<tr>
<td>75</td>
<td>40</td>
<td>18.2</td>
<td>1750</td>
<td>5</td>
<td>2.3</td>
</tr>
<tr>
<td>85</td>
<td>25</td>
<td>11.4</td>
<td>2500</td>
<td>3</td>
<td>1.4</td>
</tr>
<tr>
<td>95</td>
<td>13</td>
<td>5.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Population of accepting compensation</td>
<td>172</td>
<td>78.18</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Population of refusing to pay</td>
<td>48</td>
<td>21.82</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>220</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 2 The percentages of different patterns of accepted compensation

6.2 Estimation of WTP and WTA

Generally speaking, interviewees would be influenced by the characteristics of his or own conditions when they are asked about their willingness to make a bid, such as sex, age, profession, educational level and family income. Considering the influence of relevant variables, maximum function estimation method is applied in this paper to study the relation between the bid value, and the nature of products. The logarithm normal distribution is explained as the variable \( \delta \).

If the influences of relevant variables are considered, following models are formed to calculate the estimated value of WTP:

\[
\ln WTP = \alpha X + \mu 
\]

(3)

\[
E(WTP) = \exp(\alpha X + \delta^2 / 2 )
\]

(4)

where \( X \) is some basic characteristics of interviewees and the variables are as follow: \( \alpha \) is the estimated variables; \( \mu \) is the random variable of normal distribution of \( [0, \delta] \) and \( \ln WTP \) also follow the distribution of \( [0, \delta^2] \). \( \delta \) is the standard error of normal distribution function and \( \delta^2 \) is the variable of normal distribution. According to formula (3), the value of \( \alpha \) and \( \delta \) was known. Then, the average willingness to pay was concluded based on formula (4).

The value of WTA is also concluded based on following model:

\[
\ln WTA = \alpha X + \mu 
\]

(5)

\[
E(WTA) = \exp(\alpha X + \delta^2 / 2 )
\]

(6)

The significance of \( X, \alpha, \mu, \delta \) is similar to formula (3) and (4).

Then, based on EVIEWS6.0 statistics software, WTP calculation model was made and shown in Table 4.

Table 4 The regression result of WTP and related variables of Liao River watershed interviewees

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient</th>
<th>( t ) value</th>
<th>( P ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>3.068 986</td>
<td>3.672 320</td>
<td>0.000 3</td>
</tr>
<tr>
<td>SEX</td>
<td>0.509 224</td>
<td>1.778 757</td>
<td>0.076 7</td>
</tr>
<tr>
<td>AGE</td>
<td>-0.190 039</td>
<td>-1.593 196</td>
<td>0.112 6</td>
</tr>
<tr>
<td>JOB</td>
<td>-0.157 452</td>
<td>-2.890 095</td>
<td>0.004 3</td>
</tr>
<tr>
<td>EDU</td>
<td>0.028 632</td>
<td>0.275 443</td>
<td>0.783 2</td>
</tr>
<tr>
<td>INC</td>
<td>0.169 142</td>
<td>3.237 360</td>
<td>0.001 4</td>
</tr>
<tr>
<td>( \delta )</td>
<td>1.924 608</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Therefore, the anticipated value of WTP is as follow:

\[
E(WTP) = \exp(\alpha C + \alpha_2 \text{SEX} + \alpha_3 \text{AGE} + \alpha_4 \text{JOB} + \alpha_5 \text{EDU} + \alpha_6 \text{INC} + \delta^2 / 2 ) = 161.43 \text{ Yuan/People} \cdot \text{Year}
\]

\( \alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6 \) are the coefficient of SEX, AGE, JOB, EDU, and INC. \( \text{SEX}, \text{AGE}, \text{JOB}, \text{EDU}, \text{INC} \) stands for the mean value. The concrete value is shown in Table 1.

EVIEWS6.0 software is applied to calculate WTA as shown in Table 5.

Table 5 The regression result of WTA and related variables of Liao River watershed interviewees

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient</th>
<th>( t ) value</th>
<th>( P ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>1.705 308</td>
<td>1.812 606</td>
<td>0.071 3</td>
</tr>
<tr>
<td>SEX</td>
<td>0.746 644</td>
<td>2.317 019</td>
<td>0.021 5</td>
</tr>
<tr>
<td>AGE</td>
<td>0.111 438</td>
<td>0.829 880</td>
<td>0.407 5</td>
</tr>
<tr>
<td>JOB</td>
<td>-0.000 299</td>
<td>-0.004 880</td>
<td>0.996 1</td>
</tr>
<tr>
<td>EDU</td>
<td>0.215 824</td>
<td>1.844 308</td>
<td>0.066 5</td>
</tr>
<tr>
<td>INC</td>
<td>-0.065 721</td>
<td>-1.117 373</td>
<td>0.265 1</td>
</tr>
<tr>
<td>( \delta )</td>
<td>2.166 642</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
7 Conclusions and discussions

7.1 Conclusions  The WTP and WTA of residents in Liao River Basin are studied based on CVM method. Results suggested that based on without considering other factors, the WTP of local interviewees is 125.09 Yuan/People·Year and the WTA is 196.35 Yuan/People·Year. If the basic situation of interviewees is considered, the WTP would be 161.43 Yuan/People·Year and the WTA would be 350.51 Yuan/People·Year. Results suggest that there is a large gap between the WTA and WTP. The mean value of WTP and WTA is considered as the ecological compensation standard of 160.72 Yuan/People. Therefore, the establishment of ecological compensation mechanism in Liao River Basin needs relevant policies to support. Following suggestions are put forward.

Firstly, mixed financial transferring payment system is established. Government should combine transferring payment with vertical transferring payment. On the one hand government transfers people who contribute to environment protection, and on the other hand, the government insists on the principle of "whoever pollutes compensates, whoever makes profits pays".

Secondly, there are various ways to compensate. In the field investigation, interviewees put forward many other ways to compensate. Therefore, relevant governments comply with the willingness of local residents and provide various ways to improve the ecological compensation mechanism.

Thirdly, in order to take part in the work of environment protection and treatment, government should improve the policy to involve more people into the project. This not only ensure the basic rights of local citizens, but also is beneficial to the comprehensive treatment of ecology and the establishment of long-term mechanism to protect water resources.

References

the forestry mechanism. In the reform of forestry policy, social pension fund is set aside as a part of the social insurance. In the ecological construction, it is necessary to strengthen ecological construction, increase forestry coverage, improve environment quality, and to improve the forestry cultivation in China. Furthermore, it is beneficial to strengthen the construction of public facility, production equipment and investment of community economy.

Third, a social participated, highly united, coordinated and mutual intermediated carbon trading market should be built. Considering the carbon emission in China, the characteristics of reducing carbon emission in other countries and development trend of global carbon emission trade system, it is encouraged to design a system with Chinese characteristics. Besides, it is necessary to restrain the blind expansion of trading organization and to establish coordinated trading system. Right now, there are 12 trading organizations in China. The diverse carbon emission trading market is not conducive to the merge of carbon trading market in future, and can not realize the financial merge. In the end, it is necessary to develop the carbon sink in China and to evaluate the expenditure to create favorable condition for the carbon emission trading market.

The way to solve the baseline of carbon emission is the key. Thus, it is pressing to collect, monitor and renewal the carbon emission trading system.

References


(From page 16)
