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Contingent Valuation Model Based on Contoured Willingness to Pay and Empirical Analysis

Qin Gao[1], Changlin Ao[1※], Yang Jiao[1] and Rui Tong[1]

[1]*College of Engineering, Northeast Agricultural University, Harbin 150030, China*
aochanglin2002@126.com

Abstract

The distance decay effect on willingness to pay (WTP) is employed in proposing the contoured WTP and redefining the calculation model of the non-use value of environmental resources. A contoured WTP is constructed and the relevance between different contoured WTP functions is discussed to (1) establish a contingent valuation model based on the contoured WTP, (2) evaluate the non-use value of Sanjiang Plain wetlands and (3) analyze the mechanism of the effect of the distance attribute on the WTP. Taking the Sanjiang Plain wetlands as the center, the average WTP values in four concentric belts are 123.2677, 112.8544, 90.3209 and 64.3486 RMB per year, showing a step-decreasing trend. Comparison of the general WTP model, distance-effects WTP model and contingent valuation model based on the contoured WTP shows that the contoured WTP represents the mechanism of the influence of distance on the WTP more objectively, and the contingent valuation model based on the contoured WTP enriches and improves the contingent valuation theory and methodology. The research results provide a reference for determining the expense burden and benefit distribution in related environmental policy.

Keywords: *Contoured willingness to pay (WTP)·contingent valuation (CV) Model based on contoured willingness to pay·Dichotomous-choice contingent valuation·Distance decay effect·Willingness to pay*

1. Introduction

Contingent valuation is a survey-based method that randomly selects families or individuals as samples, reveals consumer preferences for public goods and services such as ecological environment resources in a hypothetical market, and infers respondents' willingness to pay (WTP) to improve, for example, environmental quality. The method can also be used to calculate the respondents' WTP (or willingness to accept, WTA) and extend the samples to the whole study region; the average WTP (or WTA) can then be used to obtain the economic benefits or losses brought about by a planning project (Zhang and Cai, 2005). Contingent valuation surveys were first proposed in theory by Ciriacy-Wantrup (1947) as a method of eliciting the market valuation of a non-market good. However, Davis (1963) was the first to use contingent valuation empirically when he estimated the ecological value of a forest. To date, more than 6000 studies have used contingent valuation in determining the value of non-market goods such as entertainment (Carson and Hanemann, 2006), environmental aesthetics and ecosystem restoration (Cai and Aguilar, 2013; Wang and Jia, 2012), biological diversity (Halkos and Jones, 2012; Kniivilä, 2006), culture and art (Báez-Montenegro *et al.*, 2012; Bostedt and Lundgren, 2010), and the public good (Saz-Salazar and Rausell-Köster, 2008).

There is consensus that the respondents' WTP for environmental improvement is closely related to the distance between the respondent and the environmental resource

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(Concu, 2007). The distance attribute is an important factor of preference heterogeneity. Stouffer (1940) thought that the respondent's motivation has a certain correlation with distance. Sutherland and Walsh (1985) found negative correlation between distance and the non-use value of the water quality of Flathead Lake. Hanink (1995) found that personal WTP decreased with an increase in the distance between the respondent and the environmental resource; *i.e.*, respondents living further away from the protection object have lower WTP. This phenomenon is called the distance decay effect. Loomis (1996) used a dichotomous-choice contingent valuation model to discuss the effect of distance on the WTP and verified again, to a certain extent, that the WTP decreases with increasing distance. Although these studies illustrated the correlation between the distance and WTP and verified the distance decay effect of the WTP, they failed to investigate the mechanism of the effect of distance on the WTP. The present paper puts forward the concept of the contoured WTP, which it then uses to construct a contingent valuation model and redefine the calculation model for the non-use value of environmental resources based on contingent valuation. Finally, empirical analysis is carried out for the wetlands of the Sanjiang Plain. The research results provide a reference in determining the distribution of the expense burden and benefit of related environmental policy.

2. Research Methods

2.1. WTP Model

The double-bounded dichotomous-choice format is a WTP elicitation method widely used in contingent valuation. There are three methods of data analysis in double-bounded dichotomous-choice contingent valuation: the use of a random utility model (Bishop and Heberlein, 1979), the use of a WTP model (Blaine *et al.*, 2005; Cameron and Huppert, 1989), and survival analysis (Abdullah and Jeanty, 2011). The WTP model is chosen in this paper.

The WTP model is a unique computational model of contingent valuation that divides the true WTP into an observed part and unobservable part (error term) (Cameron and James, 1987) . We assume that the true individual WTP is

$$wtp_i = wtp_i^* + \varepsilon_i , \tag{1}$$

where wtp_i is the true willingness of the individual to pay, wtp_i^* is the observed part, and ε_i is the unobservable part (error term) (Bishop and Heberlein, 1979).

The respondent is willing to pay when the true WTP is greater than a given bid, in which case the answer to the elicitation questions will be "YES"; otherwise will answer will be "NO". Assume that ε_i is an independent error term. The probability of answering YES can then be expressed as

$$\begin{aligned} \text{Prob[YES]} &= \text{Prob}[wtp_i > \text{bid}_i] \\ &= \text{Prob}[\varepsilon_i > \text{bid}_i - wtp_i^*] \\ &= \text{Prob}[\varepsilon_i / \sigma > (\text{bid}_i - wtp_i^*) / \sigma] \\ &= 1 - F\left\{(\text{bid}_i - wtp_i^*) / \sigma\right\} \end{aligned} , \tag{2}$$

where bid_i is the bid presented to the i th individual, and the error term ε_i has a cumulative distribution function $F(\varepsilon_i)$ with mean zero and variance σ^2, such as a logistic distribution, log-logistic distribution, lognormal distribution, or Weibull distribution.

In the double-bounded model, respondents are faced with a two-sequence bid offer. A second bid is proposed depending on the response to the first bid. An affirmative response to the first question is followed by a stepped-up bid, and a negative response is followed by a lower bid. The responses to the two questions offer to two bounds for each latent WTP. Therefore, the double-bounded dichotomous-choice contingent valuation has four possible outcomes: (YES, YES), (YES, NO), (NO, YES), and (NO, NO). The likelihoods of these four outcomes are denoted P_{YY}, P_{YN}, P_{NY}, and P_{NN}, respectively, where P_{YY} is the probability the response is yes to both questions, and P_{YN} is the probability of a yes in response to the first question and a no in response to the second, and so on.

Accordingly, the probabilities of each outcome are

$$P_{YY} = \text{Prob}[T_i \le wtp_i, T_i^U \le wtp_i] = \text{Prob}[T_i^U \le wtp_i] = 1 - F\left\{(T_i^U - wtp_i^*)/\sigma\right\}, \tag{3}$$

$$P_{YN} = \text{Prob}[T_i \le wtp_i \le T_i^U] = F\left\{(T_i^U - wtp_i^*)/\sigma\right\} - F\left\{(T_i - wtp_i^*)/\sigma\right\}, \tag{4}$$

$$P_{NY} = \text{Prob}[T_i^L \le wtp_i \le T_i] = F\left\{(T_i - wtp_i^*)/\sigma\right\} - F\left\{(T_i^L - wtp_i^*)/\sigma\right\}, \tag{5}$$

$$P_{NN} = \text{Prob}[T_i > wtp_i, T_i^L > wtp_i] = F\left\{(T_i^L - wtp_i^*)/\sigma\right\}, \tag{6}$$

where T_i is the bid offered for the first question, T_i^U is the follow up if the answer to the first question was positive, and T_i^L is the follow up if the answer to the first question was negative.

For a given sample of n independent observations, the log-likelihood function is

$$\ln L = \sum_{i=1}^{N} \{ d_i^{YY} \ln P_{YY} + d_i^{YN} \ln P_{YN} + d_i^{NY} \ln P_{NY} + d_i^{NN} \ln P_{NN} \}, \tag{7}$$

where d_i^{YY}, d_i^{YN}, d_i^{NY}, and d_i^{NN} are dummy variables. d_i^{YY} takes the value of 1 if the respondent accepts both the initial and higher bid, and takes the value of zero if the response is otherwise. d_i^{YN} takes the value of 1 if the respondent accepts the initial bid offer but rejects the higher bid offer, and takes the value of zero otherwise. d_i^{NY} takes the value of 1 if the respondent rejects the initial bid offer but accepts the lower bid offer, and takes the value of zero otherwise. d_i^{NN} takes the value of 1 if the respondent rejects both the initial and lower bid, and takes the value of zero if the response is otherwise.

We can assume that the underlying distribution of wtp_i, conditional on individual characteristics contained in the vector x_i, has a logistic (rather than a normal) distribution, and the WTP function is a linear form in the econometric model

$$wtp_i = wtp_i^* + \varepsilon_i = x_i'\beta + \varepsilon_i. \tag{8}$$

From equations (7) and (8), the log-likelihood function for the available sample is

$$\begin{aligned} \ln L = \sum_{i=1}^{N} \Big\{ & d_i^{YY} \ln\left[1 - F\left\{(T_i^U - X_i'\beta)/\sigma\right\}\right] \\ & + d_i^{YN} \ln\left[F\left\{(T_i^U - X_i'\beta)/\sigma\right\} - F\left\{(T_i - X_i'\beta)/\sigma\right\}\right] \\ & + d_i^{NY} \ln\left[F\left\{(T_i - X_i'\beta)/\sigma\right\} - F\left\{(T_i^L - X_i'\beta)/\sigma\right\}\right] \\ & + d_i^{NN} \ln\left[F\left\{(T_i^L - X_i'\beta)/\sigma\right\}\right]\Big\} \end{aligned} \tag{9}$$

This paper applies the New-Raphson algorithm and the maximum likelihood estimate to estimate values of the model parameters.

2.2. Contingent Valuation Model Based on the Contoured WTP

On the basis of the distance decay effect of the WTP, this paper puts forward the concept of the contoured WTP and a contingent valuation model based on the contoured WTP, and redefines the calculation model of the total benefit based on the contingent valuation of the non-use value of environmental resources. Viewing the evaluation object as a point, the contingent valuation model based on the contoured WTP is established by dividing the distance between the respondent and evaluation object into several concentric belts to construct the contoured WTP, discussing the relevance between the different contoured WTP equations, and finally aggregating benefit estimates using the refined calculation model for the total benefit value.

2.2.1. WTP distance Decay Effect: Tobler's first law of geography states that everything is related spatially, and the closer the distance, the stronger the association; human behavior has absolute effects on the local region that decrease with increasing distance (Tobler, 1970).

Most previous contingent valuation studies did not include variables for measuring the effects of geographic distance from the evaluation object on the WTP, and implicitly assumed that the effects of geographic distance were moot (Concu, 2007). The assumption will affect the total economic value of the evaluating object. Specifically, by not including a distance factor, the assessment results will be less than the actual value if the sample is too limited geographically and greater than the actual value if the sample is taken over a large geographic area.

In considering the mechanism of the effect of distance on the WTP, to a certain extent, the distance between the respondent and the evaluation object can adjust demand for environmental goods as an alternative of the price mechanism. The distance factor affects the respondents' awareness of environmental goods, through affecting information validity and accessibility on the one hand and affecting the possibility of usability and substitutability of environmental goods on the other hand (Bateman *et al.*, 1999; Hanley *et al.*, 2003; Jiang *et al.*,2005; Pate and Loomis, 1997).

Distance is logically expected to negatively affect the respondents' WTP in a given region. The farther that respondents live from the assessment object, the less they are willing to pay for possible improvement and protection of environmental goods. This is the WTP distance decay effect.

This paper takes the evaluation object as a point, takes the straight-line distance between the respondent and evaluation object, and incorporates distance as an independent variable of the WTP function. In designing the question about the respondent's residence in the questionnaire, the straight-line distance between the respondent's residence and the wetlands of the Sanjiang Plain directly measured on a map is taken as the distance variable dis.

2.2.2. Construction of the Contoured WTP: Environmental preferences, which are derived from the spatial heterogeneity of the non-use value of ecological environment resources, are not stable spatially. This instability means that the WTP function varies across different geographical ranges (Concu, 2007).

Concentric belts are constructed according to the distance between the respondent and evaluation object to construct contour lines based on distance. The WTP function is then established for individual-distance and socioeconomic variables are obtained for each contour line to obtain several WTP functions. These WTP functions are collectively called the contoured WTP; *i.e.*, the WTP is described by contour lines.

The concentric belts are such that the average WTP values of the belts differ greatly. Taking the wetlands of the Sanjiang Plain as the evaluation object for empirical analysis, according to the results of several tests, we divide Heilongjiang Province into four concentric belts with the Sanjiang Plain wetlands at the center.

The distance ranges in units of kilometers are $(0,275]$, $(275,375]$, $(375,500]$ and $(500,1000]$ and they are respectively denoted D_1, D_2, D_3, and D_4, as shown in Figure 1.

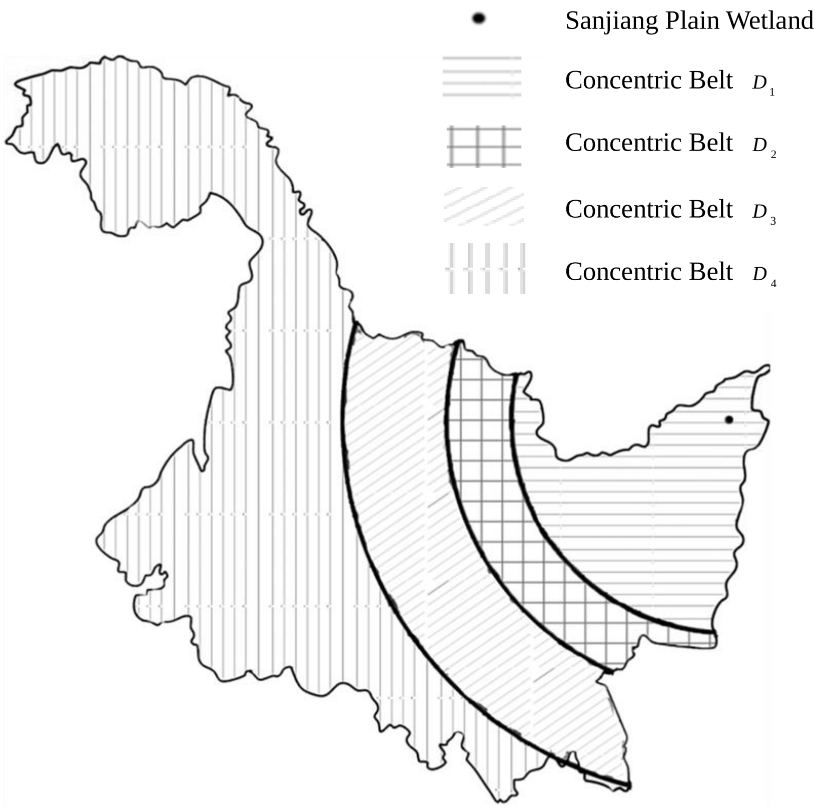

Figure 1. Four Concentric Belts Dividing Heilongjiang Province

Employing the contoured WTP, we discuss the relevance between the different contoured WTP functions to analyze the mechanism of the effect of distance on WTP.

2.2.3. Innovation in Calculating Total Benefit using Contingent Valuation Data: Through analysis of the previously established total benefit calculation model, we propose a contingent valuation model based on the contoured WTP and redefine the calculation model for total benefit.

Previous studies of aggregate benefit estimates first calculated the average WTP of all respondents in the region, and then aggregated benefit estimates to obtain the non-use value of the evaluation object. This is expressed as

$$TB = \sum_i wtp_i = \overline{wtp} * N * P^+ , \quad (10)$$

$$wtp_i = f(x_i) , \quad (11)$$

where TB is the non-use value of the evaluation object, wtp_i is the WTP of the i th individual, N is the total population in the study area, $\overline{wtp}$ is the average WTP for the whole region, P^+ is the positive payment rate for the whole region (i.e., the percentage of respondents willing to pay), and x_i are individual attributes such as socioeconomic and distance attributes. For distinction in empirical analysis, we refer to the model with only socioeconomic variables as the general WTP model and the model with socioeconomic and distance variables as the distance-effects WTP model.

In contrast to the previously established model for calculating the total benefit, the contingent valuation model based on contoured WTP first divides the study region into several concentric belts to construct the contoured WTP, then calculates the average WTP for each concentric belt to obtain the total WTP for each concentric belt, and finally aggregates the total benefit for the whole study region to give the non-use value of the evaluation object. This is expressed as

$$TB = \sum_i \sum_j wtp_{ij} = \sum_j \overline{wtp}_j * N_j * P_j^+ , \tag{12}$$

$$wtp_{ij} = f_j(x_i) , \tag{13}$$

where wtp_{ij} is the WTP of the i th individual in the j th concentric belt (i.e., the j th contoured WTP expression), N_j is the population of the j th concentric belt, $\overline{wtp}_j$ and P_j^+ are respectively the average WTP and the positive payment rate of the j th concentric belt, and x_i are individual attributes.

Compared with the previous calculation model of total benefit, the contingent valuation model based on contoured WTP considers not only the distance factor but also the extent of and change in the factor. The effect of attribute factors on the WTP is different on different contours. Specifically, there are different WTP functions for the different contours.

3. Empirical Design

3.1. Questionnaire Design

We take the wetlands of the Sanjiang Plain as the evaluation object in a double-bound dichotomous-choice contingent valuation questionnaire, with the aim to evaluate the non-use value of the wetlands. Following existing research (Ao *et al.*, 2010; Feng *et al.*, 2012), employing the Delphi technique and carrying out a preliminary investigation, we determined the contents and initial bids of the questionnaire. We designed the questionnaire by taking Heilongjiang Province as the total study area. Using principles of stratified sampling, the total amount investigated and the amount investigated in each region were determined with comprehensive reference to the proportional distribution and Neyman allocation. A preliminary survey was carried out from April to May 2011 with 90 questionnaires returned. By fully simulating a real market, obtaining feedback on the preliminary survey and improving questions and expressions, we designed the following questionnaire content.

The first part of the questionnaire was an investigation of the respondent’s awareness of the Sanjiang Plain wetlands, including the degree of understanding and the degree of concern for the wetlands, as well as other information such as the respondent’s attitude to the status quo of environmental protection and development, and the level of tourism in recent years.

The second part of the questionnaire was a guide to the double-boundary dichotomous-choice contingent valuation, and included the bid amounts and reasons to protest against payment. The annual WTP range was 1–200 RMB and the initial bid amounts were 1, 5, 10, 20, 50, 100, and 200 RMB (in questionnaires A, B, C, D, E, F and G respectively). The core problem of the dichotomous-choice contingent valuation is shown in Figure 2.

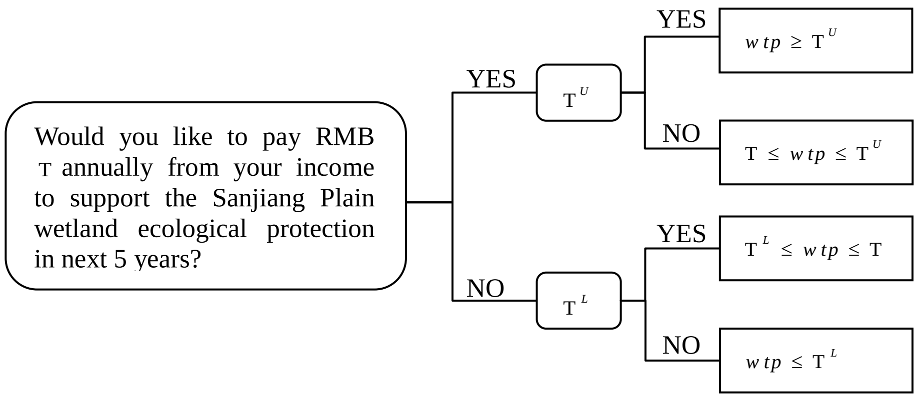

Figure 2. The Core Issue of the Dichotomous-Choice Contingent Valuation

The third part of the questionnaire was a survey of the social, economic and geographical attributes of the respondents. The variables are given in Table 1.

Table 1. Social, Economic and Geographical Attributes of Respondents

Variable	Sign	Definition of variables
Gender	male	Ordinal variable, male and female
Age	age	Continuous variable, years
Education	edu	Ordinal variable, five grades, under primary school to postgraduate
Income	inc	Ordinal variable, eight grades, annual income under 3000 to over 60,000 Yuan
distance	dis	Continuous variable, kilometer

3.2. Distribution and Collection of Questionnaires

A total of 1197 questionnaires were collected, of which 1003 were in the form of face-to-face interviews and 194 were in the form of Internet surveys; the recovery rates were 77% for the interviews and 29.1% for the Internet surveys. We obtained 927 valid questionnaires after screening, among which 326 were protest questionnaires. The positive payment rate (i.e., the rate of respondents willing to pay) for the overall region was 64.8%. The basic statistics of the questionnaire are given in Table 2.

Table 2. The WTP Distribution of Double-Bounded Dichotomous-Choice Contingent Valuation

Type	T	T^U	T^L	YY		YN		NY		NN		sum		refuse to pay	Effective Responses
				count	ratio	count	ratio	count	ratio	count	ratio	count	ratio		
A	1	3		91	96.8%	3	3.2%		0.0%		0.0%	94	100%	39	133
B	5	10	3	80	89.9%	5	5.6%	3	3.4%	1	1.1%	89	100%	51	140
C	10	20	5	75	84.3%	7	7.9%	5	5.6%	2	2.2%	89	100%	36	125
D	20	30	10	57	77.0%	6	8.1%	7	9.5%	4	5.4%	74	100%	37	111
E	50	100	30	57	67.1%	11	12.9%	11	12.9%	6	7.1%	85	100%	53	138
F	100	200	50	34	44.7%	21	27.6%	16	21.1%	5	6.6%	76	100%	57	133
G	200	500	100	32	34.0%	29	30.9%	18	19.1%	15	16.0%	94	100%	53	147
sum				426	70.9%	82	13.6%	60	10.0%	33	5.5%	601	100%	326	927

3.3. Basic Statistics of the Questionnaire in Concentric Belts

Quantitative statistics of the responses in the different concentric belts are given in Table 3. There were 261, 315, 99 and 252 effective questionnaires collected for the concentric belts D_1, D_2, D_3 and D_4 respectively, among which there were 86, 94, 40 and 106 protest questionnaires respectively, giving positive payment rates of 67.0%, 70.2%, 59.6% and 57.9% respectively. The positive payment rate thus had a decreasing tendency from inner to outer concentric belts, representing a distance decay effect of the WTP in a way.

Table 3. Questionnaire Quantitative Statistics for Concentric Belts

Belts	YY		YN		NY		NN		refuse to pay		positive percentage	sum	
	count	ratio	count	ratio	count	ratio	count	ratio	count	ratio		count	ratio
D_1	125	47.9%	29	11.1%	14	5.4%	7	2.7%	86	33.0%	67.0%	261	100%
D_2	159	50.5%	26	8.3%	23	7.3%	13	4.1%	94	29.8%	70.2%	315	100%
D_3	35	35.4%	9	9.1%	7	7.1%	8	8.1%	40	40.4%	59.6%	99	100%
D_4	107	42.5%	18	7.1%	16	6.3%	5	2.0%	106	42.1%	57.9%	252	100%
sum	426	46.0%	82	8.8%	60	6.5%	33	3.6%	326	35.2%	64.8%	927	100%

4. Empirical Results

4.1. Individual Benefit Estimates

Using the questionnaire data, we estimated the model parameters of the general WTP model, distance-effects WTP model and contingent valuation model based on the contoured WTP. We thus obtain the corresponding WTP equation and average WTP estimation.

4.1.1 General WTP model: Using only the socioeconomic variables in the model yields

$$wtp_i = \beta_0 + \beta_1 male_i + \beta_2 age_i + \beta_3 edu_i + \beta_4 inc_i + \varepsilon_i \, . \tag{14}$$

The estimation results are given in Table 4.

Table 4. Regression Results of the General WTP Model

variable	coefficients	Standard error	Wald chi-square	Sig。	confidence interval Lower Bound	confidence interval Upper Bound	Variable mean
Intercept	84.1642	2.7155	960.6	<.0001	78.8419	89.4866	
male	1.888	0.5459	11.96	0.0005	0.8181	2.9579	0.457571
age	-2.1303	0.4283	24.74	<.0001	-2.9696	-1.2909	2.868552
edu	3.9045	0.657	35.32	<.0001	2.6169	5.1921	3.492513
inc	1.2918	0.2059	39.36	<.0001	0.8883	1.6954	3.399334

The resulting expression for WTP obtained from regression is

$$wtp_i = 84.1642 + 1.888 male_i - 2.1303 age_i + 3.90451 edu_i + 1.2918 inc_i \, . \tag{15}$$

According to the model estimation, the respondent's WTP at the 0.0001 level was positively correlated with gender, educational background and income, and negatively correlated with age. This conclusion is similar to the consumer behavior of an actual market, in line with the basic principles of economics.

The calculated average WTP is then $\overline{wtp} = 96.9450$.

4.1.2. Distance-effects WTP Model: Distance as an independent variable was incorporated into the WTP function to establish the WTP function of the individual-distance variable and socioeconomic variable:

$$wtp_i = \beta_0 + \beta_1 dis_i + \beta_2 male_i + \beta_3 age_i + \beta_4 edu_i + \beta_5 inc_i + \varepsilon_i . \quad (16)$$

The estimation results are given in Table 5.

Table 5. Regression Results of the Distance-Effects WTP Model

variable	coefficients	Standard error	Wald chi-square	Sig。	confidence interval		Variable mean
					Lower Bound	Upper Bound	
Intercept	46.3587	2.226	433.74	<.0001	41.9959	50.7215	
dis	-0.087	0.002	1826.83	<.0001	-0.0909	-0.083	344.5938
male	1.0284	0.6739	2.33	0.127	-0.2924	2.3493	0.457571
age	-2.8902	0.4461	41.98	<.0001	-3.7645	-2.0158	2.868552
edu	19.7798	0.4294	2121.85	<.0001	18.9382	20.6214	3.492513
income	2.5257	0.1949	167.92	<.0001	2.1437	2.9077	3.399334

The resulting expression for WTP obtained from regression is

$$wtp_i = 46.3587 - 0.087 dis + 1.0284 male - 2.8902 age + 19.77981 edu + 2.5257 income . \quad (17)$$

According to the model estimation results, respondents' WTP at the 0.0005 level was positively correlated with gender, educational background and income level, while being negatively correlated with age and distance. The model results verify that the WTP has a distance decay effect.

The calculated average WTP is then $\overline{wtp} = 86.2258$.

4.1.3. Contingent Valuation Model Based on the Contoured WTP: The WTP function of the individual-distance and socioeconomic variables was established for the concentric belts D_1, D_2, D_3 and D_4. This is expressed as

$$WTP = \begin{cases} \beta_{10} + \beta_{11} dis + \beta_{12} male + \beta_{13} age + \beta_{14} edu + \beta_{15} income + \varepsilon_1, & D_1 \\ \beta_{20} + \beta_{21} dis + \beta_{22} male + \beta_{23} age + \beta_{24} edu + \beta_{25} income + \varepsilon_2, & D_2 \\ \beta_{30} + \beta_{31} dis + \beta_{32} male + \beta_{33} age + \beta_{34} edu + \beta_{35} income + \varepsilon_3, & D_3 \\ \beta_{40} + \beta_{41} dis + \beta_{42} male + \beta_{43} age + \beta_{44} edu + \beta_{45} income + \varepsilon_4, & D_4 \end{cases} . \quad (18)$$

The estimation results are given in Table 6.

Table 6. Regression Results of the Contingent Valuation Model Based on the Contoured WTP

Belts	variable	coefficients	Standard error	Wald chi-square	Sig.	confidence interval		Variable mean	$\overline{wtp}_j$
						Lower	Upper		
D_1	Intercept	-0.4274	5.1955	0.01	<.0001	-10.6103	9.7556		123.2677
	dis	-0.3847	0.0104	1566.28	<.0001	-0.4331	-0.3922	139.68	
	male	-13.0755	6.4863	4.06	<.0001	-25.7884	-0.3626	0.56	
	age	4.6482	3.2289	2.07	0.006	-1.6803	10.9766	2.97	

	edu	38.9792	1.6551	554.67	<.0001	35.7354	42.2231	3.46	
	income	9.5509	1.658	33.18	<.0001	6.3012	12.8006	3.79	
	Intercept	39.1678	17.7361	4.88	0.0272	4.4057	73.93		
	dis	-0.0724	0.0513	1.99	0.158	-0.173	0.0281	289.66	
D_2	male	32.9365	1.9949	272.6	<.0001	29.0267	36.8464	0.43	112.8544
	age	-20.9225	1.4435	210.1	<.0001	-23.7516	-18.0934	2.86	
	edu	29.0986	1.0178	817.33	<.0001	27.1037	31.0935	3.39	
	income	11.8998	0.9044	173.12	<.0001	10.1272	13.6724	3.5	
	Intercept	-26.2869	11.0497	5.66	0.0174	-47.9439	-4.6299		
	dis	0.0704	0.0378	3.47	0.0625	-0.0037	0.1444	443.17	
D_3	male	14.9421	1.3581	121.05	<.0001	12.2803	17.604	0.36	90.3209
	age	-1.2496	0.8569	2.13	0.1447	-2.929	0.4298	2.69	
	edu	22.4671	0.5106	1936.13	<.0001	21.4664	23.4679	3.37	
	income	3.2131	0.3077	109.01	<.0001	2.61	3.8163	2.39	
	Intercept	-136.528	6.2602	475.62	<.0001	-148.798	-124.258		
	dis	0.3268	0.0074	1947.82	<.0001	0.3123	0.3413	633.52	
D_4	male	7.4956	1.0761	48.52	<.0001	5.3866	9.6047	0.42	64.3486
	age	-1.9016	0.4004	22.55	<.0001	-2.6864	-1.1167	2.82	
	edu	-1.3476	0.4628	8.48	0.0036	-2.2548	-0.4405	3.73	
	income	0.3472	0.2504	1.92	0.1656	-0.1436	0.8379	3.18	

The resulting expressions for WTP obtained from regression are

$$\mathrm{WTP}_{D_1} = -0.4274 - 0.3847dis - 13.0755male + 4.6482age + 38.9792edu + 9.5509income\,, \quad (1)$$

$$\mathrm{WTP}_{D_2} = 39.168 - 0.0724dis + 32.937male - 20.923age + 29.099edu + 11.899income\,, \quad (2)$$

$$\mathrm{WTP}_{D_3} = -26.287 + 0.0704dis + 14.942male - 1.2496age + 22.467edu + 3.213income\,, \quad (3)$$

$$\mathrm{WTP}_{D_4} = -136.528 + 0.327dis + 7.496male - 1.902age - 1.3476edu + 0.347income\,. \quad (4)$$

The contour WTP is thus expressed as

$$\mathrm{WTP} = \begin{cases} -0.4274 - 0.3847dis - 13.0755male + 4.6482age + 38.9792edu + 9.5509income, & D_1 \\ 39.168 - 0.0724dis + 32.937male - 20.923age + 29.099edu + 11.899income, & D_2 \\ -26.287 + 0.0704dis + 14.942male - 1.2496age + 22.467edu + 3.213income, & D_3 \\ -136.528 + 0.327dis + 7.496male - 1.902age - 1.3476edu + 0.347income, & D_4 \end{cases} \quad (5)$$

The model estimation results reveal the following.

(1) The average pay levels in the concentric belts D_1, D_2, D_3 and D_4 were 123.2677, 112.8544, 90.3209 and 64.3486 RMB per year, revealing a stepwise decreasing trend and further verifying that the WTP has a distance decay effect. The average pay levels in the four concentric belts had large differences, which is consistent with the design principle of the concentric belts and in line with theoretical expectations.

(2) The respondent's WTP was positively correlated with the distance variable in belts D_1 and D_2, and negatively correlated in belts D_3 and D_4; however, there was a stepwise decreasing trend on the whole. This suggests that when the distance exceeded a certain range, its effect on WTP weakened, and it was not the dominant effect on the WTP. This is not contrary to the principle of the distance decay of WTP, and gives a better understanding of the mechanism of the influence of distance on the WTP.

(3) Factors such as gender, age, educational background, income level and distance significantly affect the WTP, and within different distance ranges, the effects and extents of effects of each attribute on WTP varies, which to some extent

indicates to the necessity of establishing the contoured WTP.

4.2. Aggregated Benefit Estimates

Populations of administrative regions in Heilongjiang Province according to the sixth national census data communiqué of China, and the estimation results of the three models given above, were used to calculate the non-use value of the Sanjiang Plain wetlands.

The regional total WTP obtained with the general WTP model and distance-effects WTP model was calculated using equation (1), while that obtained with the contingent valuation model based on the contoured WTP was calculated using equation (4). The calculation results are given in Table 7. The total WTP in Heilongjiang Province in 2011 was calculated as 2.4068, 2.1407 and 1.8782 billion RMB per year respectively using the three models; these are the non-use values of the Sanjiang Plain wetlands in 2011.

Table 7. Aggregated Benefit Estimates Obtained with the Three Models

	Region range	positive payment rate p^+	regions population	Average wtp	The region total WTP
general WTP model	Heilongjiang Province	0.648	38312224	96.9450	2406787704.0
distance effects WTP model	Heilongjiang Province	0.648	38312224	86.2258	2140669402.0
contingent valuation Model Based on Contoured WTP	D_1	0.67	3571186	123.2677	294941962.6
	D_2	0.702	5476811	108.5392	417302976.5
	D_3	0.596	4561609	90.32088	245557089.3
	D_4	0.579	24702618	64.34861	920366317.2
	Heilongjiang Province				1878168346.0

If a distance factor is not included and if the sample is taken from a large geographical area, the assessment results will be greater than the actual value. By comparing results obtained with the general WTP model, distance-effects WTP model and contingent valuation model based on the contoured WTP, it is seen that the contoured WTP more objectively reflects the effect of the distance on the WTP, and that contingent valuation based on the contoured WTP made the contingent valuation evaluation more scientific and objective.

5. Discussion and Conclusions

Employing the distance decay effect of the WTP, this paper put forward the concept of the contoured WTP and the contingent valuation model based on the contoured WTP, and redefined the calculation model for the aggregate benefit based on contingent valuation to obtain the non-use value of environmental resources. Taking the Sanjiang Plain wetlands as a case study, the paper took the evaluation object as a point and the straight-line distance between the respondent and evaluation object as the distance. With the evaluation object at the center, the distance between the respondent and evaluation object was divided into concentric belts to construct contour lines based on distance; study the WTP function for individual distances and socioeconomic variables on the contour lines; and discuss the relevance between the different contoured WTP functions to analyze the mechanism of the effect of distance on the WTP. The main results of the study are as follows.

(1) A total of 927 valid questionnaires were obtained in Heilongjiang Province. The positive payment rate was 64.8%. Taking the Sanjiang Plain wetlands as the center of four concentric belts that divide Heilongjiang Province with radii of $(0,275]$, $(275,375]$, $(375,500]$ and $(500,1000]$, the positive payment rate in the four concentric belts were 67.0%, 70.2%, 59.6% and 57.9% respectively, and the average pay level was 123.2677, 112.8544, 90.3209 and 64.3486 RMB per year respectively, showing a step-decreasing trend.

(2) The total WTP in Heilongjiang Province in 2011 calculated by the general WTP model, distance-effects WTP model and the contingent valuation model based on the contoured WTP was respectively 2.4068, 2.1407 and 1.8782 billion RMB per year; these are the non-use values of the Sanjiang Plain wetlands in 2011. The research results showed that the contoured WTP more objectively reflects the effect of distance on WTP, and contingent valuation based on the contoured WTP is more scientific and objective.

The WTP models were used to analyze factors of a resident's WTP, with model parameters estimated by maximum likelihood estimation. The results show that gender, age, educational background, income level and distance significantly affect WTP, and the effects and extents of effects of each attribute variable on WTP varied at different distance ranges, which to some extent indicates to the necessity of establishing the contoured WTP.

We believe that the contingent valuation model based on the contoured WTP will play an important role in estimating non-use values, and its development lays the theoretical foundation for establishing benefit and cost distributions in ecological environment policy.

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