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Using Double-Bounded Dichotomous-Choice to Estimate Households' Willingness to Pay for Improved Water Quality in Bac Ninh Province of Vietnam

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Abstract

This study used double-bounded dichotomous-choice to estimate and analyze the factors affecting households' willingness to pay (WTP) for water quality improvement. This study notes that households with higher income, living near polluted water source, using tap water instead of natural water, who are handicraft producers, and who have more members are willing to pay more. However, households who rarely hear about environmental pollution issues and who are offered a higher bid are more likely to refuse to pay. Solutions to improve water quality are suggested such as to raise people's awareness through communication channels and social organizations; to increase income associated with environmental protection policies; to construct wastewater treatment plants; to encourage the relocation of production establishments to industrial parks and industrial complexes; to put regulations on collection, payment and sanctions in case of not declaring and paying fees into village conventions; to promulgate circulars, and bylaws to concretize and simplify regulations and policies of the Government, Ministry of Natural Resources and Environment.

Key words: *Double-bounded dichotomous-choice, willingness to pay, water quality improvement, handicraft households*

I. PROBLEM STATMENTS

Despite having a small total area, Bac Ninh province is a province with a large number of traditional handicraft villages. Its total production value from handicraft villages was nearly 8,000 billion VND (around 381 million USD), accounting for approximately 8% of the annual provincial GDP) (Bac Ninh Provincial People's Committee, 2015). In 2016, there were over 13,000 handicraft households in the province (Department of Natural Resources and Environment of Bac Ninh Province, 2017).

While the handicraft industry has contributed significantly to the local economy, the results of surface water analysis, however, revealed that the concentrations of pollutants exceeded the Vietnam Permissible Standards (VPS) several times. At the agricultural processing villages, the BOD_5 levels exceeded 5.8-56.3 times the VPS; the COD levels exceeded 28.2 times the VPS; while the TSS, ammonia, and coliform levels exceeded VPS more than 10 times. In comparison with the figures for 2016, the pollutants' contents in wastewater in 2018 increased 3-4 times. It is of note that the coliform in the wastewater sample collected in 2018 was 300 times as high as that in 2016 (Centre for Monitoring Environment Quality, 2018). This shows that water pollution in Bac Ninh's handicraft villages is becoming more and more severe.

In Dai Bai, Bac Ninh province, for instance, wastewater from casting copper exceeded VPS dozens to hundreds of times. The volume and characteristics of wastewater produced vary from village to village, depending on the type of technology and materials used in production. Food processing and textile dyeing industries that use large amounts of water discharge large volumes of wastewater with high organic pollution levels. The volume of wastewater of these villages is from 2,000 to 5,000 m^3/day. Weaving, carpentry, and paper making villages also use up chemicals that pollute wastewater (Centre for Monitoring Environment Quality 2014). According to experts, the wastewater from handicraft villages and industrial zones has resulted in heavy pollution of Cau and Ngu Huyen Khe rivers.

By virtue of Decision No. 404/QD-UBND of the Bac Ninh province, the implementation of environmental protection fees for industrial wastewater was promulgated in 2013. The regulation on environmental protection states that households, production establishments, and service organizations in handicraft villages are responsible for waste disposal. They must ensure waste standards and contribute funds for infrastructure to protect the environment.

However, this regulation has never been implemented in handicraft villages. While Bac Ninh province had some wastewater treatment plants, the wastewater treatment system in Khac Niem, for instance, was used for one year only because the system did not meet the required volume of wastewater from vermicelli making. Moreover, the wastewater treatment system in Dai Bai operated only in 2 years due to a lack of funds.

There have been many studies on pollution issues in handicraft villages of Bac Ninh province. However, these studies focused primarily on the pollution status and technical solutions. The studies of Nguyen Thi Tham (2011), Dam The Chien (2014), and Le Thi Thanh Thuy (2014) showed that wastewater from handicraft villages is seriously polluted, people in handicraft villages suffer from common diseases, and the estimated medical cost of people are 1.5 to 3 times higher than residents in pure agricultural villages.

Bac Ninh government's solution focuses on building wastewater treatment plants. A study of people's willingness to pay to improve water quality is important. This can help in assessing financial issues as well as people's welfare from water quality improvement program. Hence, this study aimed to analyze people's opinion on water pollution and water quality improvement, estimate people's willingness to pay, and identify the factors the affect willingness to pay for water quality improvement.

II. REVIEW OF LITERATURE

Contingent valuation (CV) is one of the commonly used methods by economists, policy makers, and water utility organizations to improve water supply (Parry-Jones 1999). It is a direct approach to elicit the willingness and ability to pay of a person on something (Mitchell and Carson 1989). It is considered a way to directly elicit preferences, abilities, and ideas from consumers (Kahneman and Knetch 1992 and Whitehead, *et al.* 2000). CVM method not only helps "buyer" focus on economic values, but also analyzes a series of economic values in the mind, their locations or the distribution of valuation to the respondents (Cameron and Quiggin, 1994; Li and Mattsson, 1995; and Ready, *et al.* 1995). Welsh and Bishop (1993) and Welsh and Poe (1998) present a wide selection of discrete approaches to ask respondents questions about the degree of certainty in a variety of price levels. Wang (1997a & 1997b) showed that uncertainty is an inherent characteristic of the people's economy for commodity pricing of market and non-market goods.

Dale, *et al.* (1990) estimated the level of willingness to pay for water services in developing countries and found no evidence of deviation from the initial point of the suggested methods of generating between the two groups investigated. Furthermore, willingness to pay (WTP) was positively related to household income, occupation, education level, and distance from water sources. T.T.T. Trang, et al (2019) pointed out the major factors affecting their willingness to pay for the establishment of a wastewater treatment plant are their level of education, quantity of households' untreated wastewater.

Some methods try to "price" non-market goods by examining the relationship of "price" with market rules. Brox, *et al.* (2013) estimated the WTP for improved water quality in residential areas in the Grand River basin in the Province of Ontario, Canada, and Barton (2002) used an identical method to find the WTP. Additionally, Atkins, *et al.* (2007) applied CVM, decision tree analysis and investigation of the willingness to pay for improved water quality. Studies by Barton (2002), Atkins, *et al.* (2007), Gupta and Mythili (2008), and Brox *et al.* (2013) likewise used the CVM method. T.T.T Trang, et al (2018) applied Experiment (CE) technique in Choice Modelling (CM) approach for the study. The results showed that total annual environmental fee for wastewater treatment.

Double-bounded dichotomous choice (DBDC) is one of the elicitation procedures. With DBDC, the respondent says 'yes' or 'no' to a stated sum and is then asked to say 'yes' or 'no' to higher/lower bids. This technique is more efficient than single-bounded dichotomous choice (SBDC) as more information is elicited about the respondent's WTP. However, all the limitations of the SBDC still apply, such as: (i) the values obtained from dichotomous choice elicitation are significantly larger than those resulting from comparable open-ended question; (ii) some degree of yes-saying is also possible, and iii) the starting point is biased (Bateman *et al.*, 2002).

By employing DBDC, Jinsoo and Jihyo (2015), Abdullaha and Jeantyc (2011), and Nasreen *et al.* (2014) confirm the conclusions by Haab and Mc Connell (2002) that there are three ways why which DBDC is more efficient than the single-bounded format. First, the 'yes-no' and 'no-yes' provide a clear bound of WTP; second, the 'no-no' and 'yes-yes' estimate efficiency gains; and third, the number of responses is substantially increased, especially for larger sample sizes. Some economists suppose that indignation and guilt are two sides of the same effect of applying DBDC. Indignation will occur when respondents perceive that in answering initial dichotomous choice question (DC1), they have struck a deal with the interviewer. Thus, when asked about the higher amount in subsequent dichotomous choice question (DC2), the respondents feel that the interviewer has gone back on the deal. The guilt hypothesis occurs when respondents who state 'no' to DC1 are asked a lower bid amount in DC2. This lower amount makes respondents feel a sense of social responsibility or guilt (Bateman *et al.*, 2001 and Watson and Ryan, 2004).

III. METHODOLOGIES

Survey Design and Data Collection

The household surveys consisted of three main parts: i) qualitative information about perceptions and attitudes of people about the environment, ii) WTP of households to transform the current poluted water into swimmable water, and iii) socio-economic characteristics of the respondents. The respondents were heads of the households who have principal management role

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in household's production activities and spending. Companies, on the other hand, were not included in the interview because they pay an anual environmental protection charge.

During the survey, the interviewers described the current state of water environment and the drainage systems in the handicraft villages. Using pictures, they explained that the drainage systems are broken and badly clogged with wastes. Furthermore, wastewater treatment plants and sewage system are necessary for the villages to meet the Vietnam water quality standards and for ponds and lakes to be suitable for swiming and bathing purposes. Because the costs to build and operate the wastewater treatment plant and sewer pipes are removed from Bac Ninh province's budget, environmental protection fee will be collected.

With a total of 13,171 households engaged in handicraft production in Bac Ninh province, the sample size at 95% significance level should be 400 households. However, the sample size was increased to 700 households for a more reliable estimate. The sample size per village was based on the proportion of households engaged in handicraft production to total number of households in the five villages (Figure 1). Total simple size are 1,000 households, 1000 households were devided into 5 study sites of Yen Phu, Khac Niem, Phong Khe, Dai Bai, and Da Hoi. These villages were five (5) out of the seven most seriously polluted water due to handicraft production in Bac Ninh province.

Figure 1. Map of the study area

The Payment Vehicle

The payment vehicle helps to ensure that respondents perceive the questions as "real". In order to increase the realism of CV surveys, the "local tax" was specified as payment vehicle. If the respondents decided to connect to the sewer line, then they would have to pay a fee 2 times as much when they pay their annual taxes, fees, and other charges to the People's Committe of their communes/ward. The DBDC was the question format. The elicitation decision process of respondents is shown in Figure 2 below.

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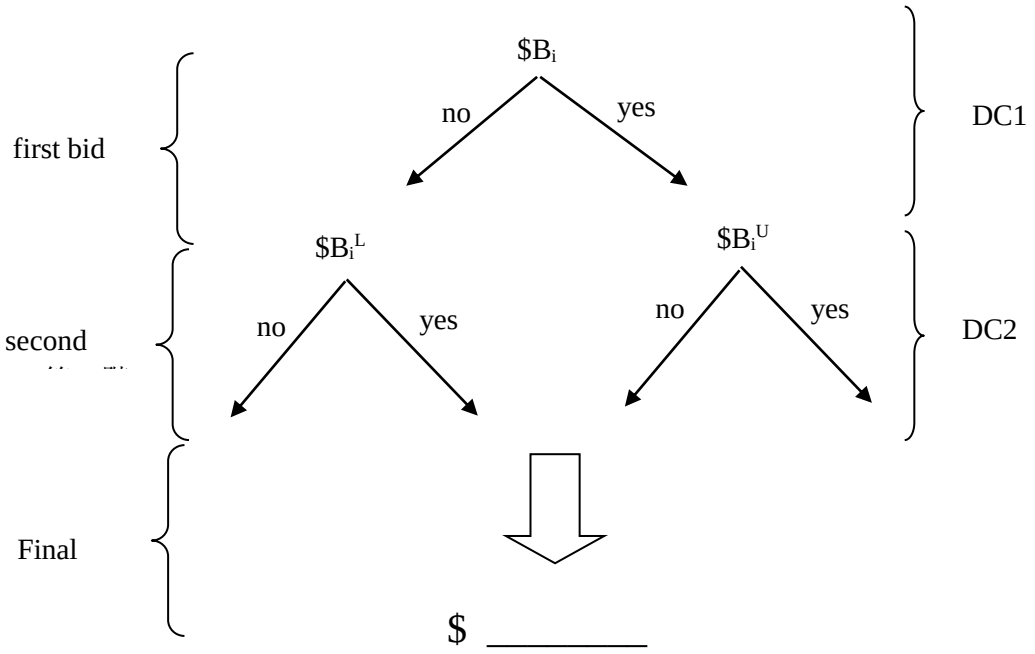

Figure 2. Elicitation decision process of willingness to pay for resources

If the respondents say "yes" to the first bid that amounts to B_i, then an iterative-bidding question with higher amount B_i^U follows. If they say "no" to the first one, a lower bid B_i^L ensues. Therefore, $B_i^L < B_i < B_i^U$.

The results with two bounded dichotomous choice include four categories: "yes/yes", "yes/no", "no/yes", and "no/no". The probability, when the first bid amount B_i has the answer "yes" and the higher amount B_i^U has "no", is defined as Y_{yn}. The probability when the first bid amount B_i has the answer "no" and the lower amount B_i^L has "yes" it is defined as Y_{ny}. The probability that both are "no" is defined as Y_{nn} while the probability that both two answers are "yes" is defined as Y_{yy}. Hence,

$Y_{yy}(Bi,Biu) = Pr\{Bi \leq \max WTP \text{ and } Biu \leq \max WTP\} = 1 - G(Biu,\theta)$

$Y_{nn}(Bi, B_{iL}) = \{Bi > \max WTP \text{ and } B_{iL} > \max WTP\} = G(B_{iL},\theta)$

$Y_{yn}(B_i, B_{iu}) = Pr\{Bi \leq \max WTP \leq Biu\} = G(Biu;\theta)$

$Y_{ny}(B_{iL}, B_i) = Pr\{Bi \geq \max WTP \geq B_{iL}\} = G(Bi;\theta) - G(B_{iL};\theta)$

Given a sample of N respondents, Bi, Biu, and BID1 are the bids for the ^{i}th respondent, where d_i^{yy}, d_i^{nn}, d_i^{yn}, and d_i^{ny} are binary-valued indicator variables. The ML estimator for the double-bounded model, θ^D, is the solution to the equation $\partial \ln L^D(\theta^D)/\partial\theta = 0$, subject to $\partial 2 \ln L/\partial Q2<0$.

The log-likelihood function takes the following form:

$$LnL^D(\theta) = \sum_i^N \{d_i^{yy} \ln Y_{yy}(Bi,Biu) + d_i^{nn} \ln Y_{nn}(Bi, B_{iL}) + d_i^{yn} \ln Y_{yn}(Bi, Biu) + d_i^{ny} \ln Y_{ny}(Bi,B_{iL})$$

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The bids were based on the results of focus group discussions, pre-tests, and consultations of experts. The bids that ranged from 150,000 VND to 850,000 VND were divided into 5 categories: (150,000 – 325,000 – 500,000 – 675,000 – 850,000) for the first bid. Each respondent received one randomly drawn bid price. With the aid of a picture, the respondents were asked about their willingness to pay to change the water's current contaminated status to a clean status at an offered price ("yes" means willing to pay and "no" means not willing to pay). Accept/reject respondent probabilities were calculated for each VND amount offered. Depending on the first reply "yes" or "no", respondents are asked for their WTP for a second follow-up bid to which they can again answer either "yes" or "no". The five groups of follow-up bids are (75,000 to150,000 to 225,000); (163,000 to 325,000 to 487,000); (250,000 to 500,000 to 750,000); (338,000 to 675,000 to 1,012,000); and (425,000 to 850,000 to 1,275,000).

Follow-up Questions

Follow-up questions are especially useful when there are some forms of protests or unwillingness to pay. In this study, follow-up questions were asked to test the credibility of the responses via a Likert scale. The question was: How certain are you of your answer? Below are the choices of answers:

-2	-1	0	+1	+2
Very uncertain	Somewhat uncertain	Neutral	Somewhat certain	Very certain

Responses of "very uncertain" and "somewhat uncertain" were treated as "no", while "neutral" was considered as "yes".

Analysis of Fundamental Factors Affecting the Level of People's Willingness to Pay

The acceptance probability P is written as follows (Johannesson *et al.*, 1996):

$$P = F(B) = 1/(1+e^{-\Delta V}) \quad (1)$$

where: F(B) is the "survivor" function yielding the probability of accepting to pay at least $B.

ΔV is the change in utility caused by the considered improvement in safety if the person pays $B for the improvement, that is, $\Delta v = ß_0 + ß_1 bid + ß_2 Si$

where: S is a vector of socioeconomic factors such as age, sex, education, household size, and household income.

$ß_i$ (I = 0,1,2) are the estimated parameters.

The logistic function in equation (1) can be written as:

$$Ln\,[P/(1-P)] = ß_0 + ß_1 bid + ß_2 Si \quad (2)$$

The estimation of the coefficients using binary logistic model includes two related models which were expressed as:

$$Y_1 = ß_{01} + ß_{11} bid_1 + ß_{21} Si$$

$$Y_2 = ß_{02} + ß_{12} bid_2 + ß_{22} Si$$

where Y_1, Y_2 are the binary responses to the WTP questions; bid_1 and bid_2 are the bids in the first and second bid questions; Si represents the socio-demographic variables; $ß_{01}$, $ß_{11}$, $ß_{21}$, $ß_{02}$, $ß_{12}$, and

$ß_{22}$ are the estimated coefficients. Y, Y_1, Y_2 are the binary responses (Y = 1 if they agree to pay, Y = 0 if they do not agree to pay).

Parametric Approach to Estimate Willingness to Pay

The Mean WTP is estimated by using binary logistic model as follows:

From the model $Y= ß_0 + ß_1 bid + ß_i Xi$, we have:

$$\text{Mean WTP} = \frac{ß_0 + ß_i \overline{X_i}}{ß_1}$$

In which $\overline{X_i}$ is mean of X_i.

Estimating the Total Funding for Rehabilitation of Water Sources from People

The following formulas were used:

Real funding = Average WTP × Percentage of Households (HHs) willing to pay × Total HHs

Potential funding = Average WTP × Total HHs

IV. RESULTS AND DISCUSSIONS

Socio-economic Characteristics of Respondents

The average age of the respondents was 46 years old, men accounted for 65.1% of the total respondents. There were 43.8% of the respondents completing high school, which means more than 50% of the respondents did not completed high school. After high school, respondents often chose to live in the villages to help their family in the production activities. On the average, respondents of 36 to 45 years of age had an educational attainment of high school. Respondents who had the highest education levels belonged to the 25 to 35 years old bracket. The average household size was 5 while average household income was 15.5 million VND/month. Around half (46.8%) of the households had income under 10 million VND/month. Most of the households with income below 10 million VND/month were in villages engaged in agro-products such as noodle production and processing in Khac Niem and Yen Phu, respectively.

People's Opinion on Water Pollution and Water Quality Improvement

The environmental pollution issues are mentioned on television, radio, magazines, newspapers, and the internet. Approximately 35.6% of the respondents often learned about the problems of environmental pollution from these mass media. About 96.8% of the local people said that the most serious environmental problem in the locality was water pollution; 41.3% noted local air pollution whereas 18.6% identified the noise pollution (Figure 3). In addition, most of the respondents pointed out that the problem of environmental pollution has worsened in the past five years.

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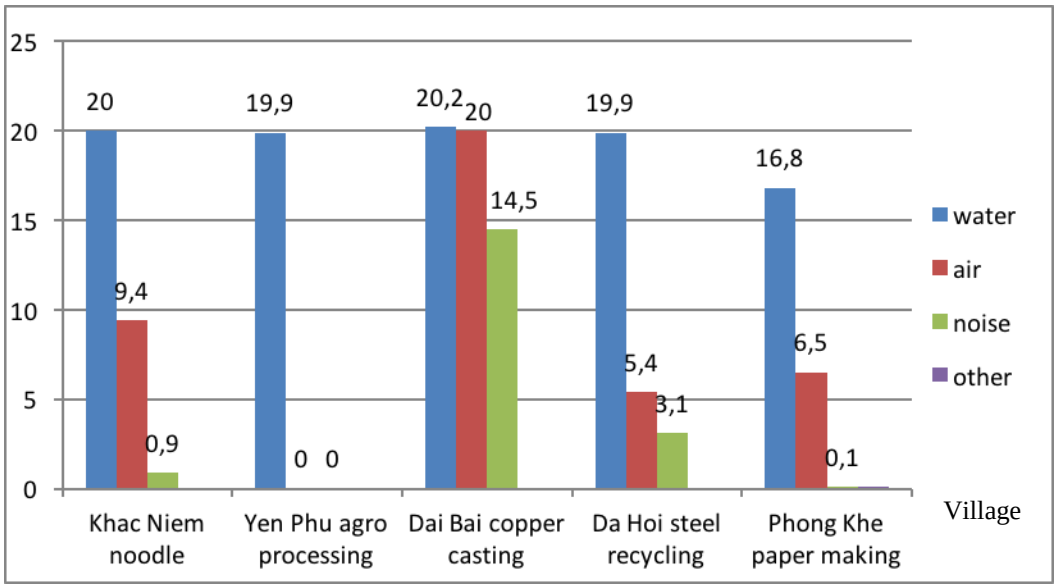

Figure 3. Assessment (% of respondents) of environmental pollution, Bac Ninh province

The biggest consequences of water pollution were chronic diseases like conjunctivitis, diarrhea, and cancer which was reported to have become more common and severe in recent years. Many people complained about the increasing expenditures on health care which affected their activities and production performance. A few respondents cited that water pollution has affected their recreational activities, entertainment, and local festivals.

Table 1. Perceptions of household respondents (%) on water pollution, Bac Ninh province

Criteria	Handicraft	Agricultural	Average
Effects of water pollution			
Health	96.21	95.77	95.90
Living activities	78.28	64.08	68.20
Economics	16.90	21.55	20.20
Productions	25.52	24.93	25.10
Others	1.38	0.99	1.10
Sources of pollution			
Household wastes	40.00	38.59	39.00
Business wastes	81.03	72.25	74.80
Wastewater from industrial parks	32.76	44.23	40.90
Others	0.34	1.69	1.30
Trade-off between income and water quality			
Do not agree	1.70	3.80	3.20
Agree	98.30	96.20	96.60
Handicraft producers should pay more			
Do not agree	15.50	24.60	22.00
Agree	84.50	75.40	78.00
Environmental policies to be integrated through village's conventions	100	100	100

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Wastewater from handicraft production activities was the main cause of environmental pollution as 81.03% of the respondents attributed the water pollution to it. They also noted the adverse effects of nearby industrial parks on water pollution. Most were aware of the pollution's harmful effects and agreed to share part of their income to improve the current water quality in their villages. The surveyed households were unanimous in integrating environmental policy in village's conventions.

Almost eight of every ten respondents (78%) argued that handicraft producers should pay higher fees than agricultural households. A few did not agree to pay for environmental improvement due to any of the following reasons: i) the water quality is not a problem, ii) it is not their responsibility to improve the quality of the water, and iii) they do not have money to pay it.

People's Willingness to Pay for Improved Water Quality

Based on DC1 model, 64.7% of the respondents are willing to pay to improve water quality (Table 2). Moreover, the percentage of "Yes"- "No" responses indicates that the acceptance rate falls when the suggested bid gets higher.

Table 2. The probability of "Yes –No" responses of households for the first bid under the DC1 model

Bid	**"Yes"**		**"No"**	
(1,000 VND)	No.	Percent (%)	No.	Percent (%)
150	187	89.05	23	10.95
325	164	73.21	60	26.79
500	131	65.83	68	34.17
675	105	60.34	69	39.66
850	60	31.09	133	69.91
Total	647	64.7	353	35.3

As shown in Figure 4, the proportion of agricultural households refusing to pay was 10% higher than handicraft households. When the given bids are increased, the percentage of handicraft households willing to pay was higher than agricultural households. Most of handicraft households think that they take more legal responsibility of water pollution and therefore have to pay for the water improvement program.

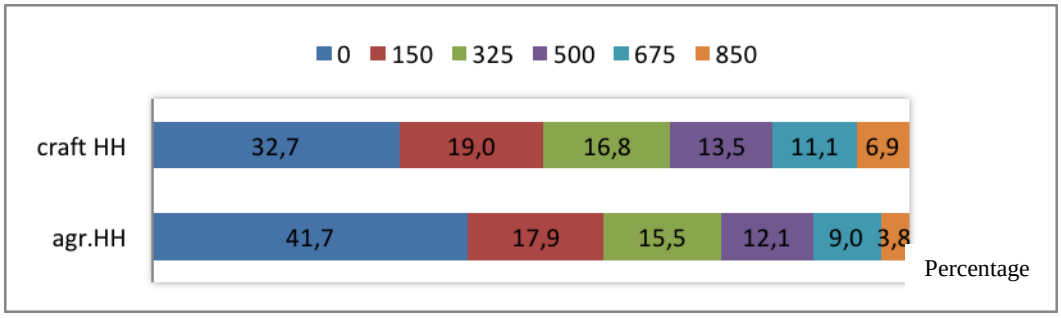

Figure 4. The willingness to pay (%) by type of households, Bac Ninh province

Depending on the first reply, i.e., "yes" or "no", the respondents were asked for their WTP for a second follow – up bid to which they answered either "yes" or "no". If the respondents

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answered "no" ("yes") to the first bid, the follow up bid is a lower (higher) amount. The results are presented in Table 3.

Table 3. Responses of households to the two suggested bids (DC2 model)

1st Bid [a]	2nd Bid [a] (higher)	2nd Bid [a] (lower)	Y/Y	Y/N	N/Y	N/N
150	225	75	173 [b] (82.38) [c]	14 (6.67)	10 (4.76)	13 (6.19)
325	487	163	124 (55.36)	40 (17.86)	35 (15.63)	25 (11.16)
500	750	250	92 (46.23)	39 (19.60)	43 (21.61)	25 (12.56)
675	1012	338	20 (11.49)	85 (48.85)	52 (29.89)	17 (9.77)
850	1275	425	10 (5.18)	50 (25.9)	61 (31.61)	72 (37.31)

[a] In 1,000 VND
[b] Number of households
[c] Percentage of households

About 82.38% of the respondents agree to pay the two given bids (150 – 225). The percentage of people saying "yes – yes" fell when the given bid was raised. About 37.31% of the respondents disagreed to pay the highest group amount of 850 - 425. This rate tends to decrease when the suggested bid decreases. At the lowest group bid (150 – 75), the percentage of "no – no" responses was only 6.19%. The results from DC2 model and DC1 model again confirm that the 'yes' response monotonically decreases (increases) as the offer amount increases (decreases), indicating that a higher bid would result in a lower probability of saying 'yes' to the WTP question.

The funding that will be obtained from people to improve the environmental quality of water was estimated according to the household types. These funds can be obtained through a socialization program on improved environment.

Table 4. Estimation of total funding to improve water quality, Bac Ninh province

Item	DC1	DC2
Mean WTP (VND)	275,816	355,821
Percentage of households who voted "yes" (%)	64.7	84.8
Total number of households	340,319	340,319
Real number of households willing to pay	220.186	288,590
Potential funding (billion VND)	93.86	121.09

Real funding (billion VND)	60.73	102.686

The total potential funding that could be collected from households at Bac Ninh's handicraft in the DC1 model and DC2 model is 93.86 million VNĐ/year (4.05 million USD/year) and 121.09 million VNĐ/year (5.23 million USD/year), respectively. The total real funding calculated based on the number of people who are willing to pay at these villages in DC1 model and DC2 model is 60.73 million VNĐ/year (2.62 million USD/year) and 102.686 million VNĐ/year (4.43 million USD/year), respectively.

A notable and preeminent feature of this parametric method is that it allows to combine, analyze and integrate respondent's characteristics for the estimation of the average willingness to pay. This method also provides researchers with information on the validity and reliability of contingent valuation methods, and on the relevance and statistical significance for model testing and allows quantitative extrapolation based on statistical tests. In addition, the coherence and logic between the socio-economic characteristics of interviewees with the willingness to pay (resulting from this approach) are very valuable for policy makers in decision making related to socio-economic-environmental characteristics, customs and practices of the residential areas. This is especially meaningful for Kinh Bac, the cradle of Quan ho singing and for the custom of respecting relatives and family relations. This method helps to estimate the average WTP heavily based on the parametric model. In other words, if the parametric model is well handled, the estimated WTP will not be sensitive to the distribution selection of the survey samples. The estimates obtained largely depend on the assumptions of the model structure, as well as the preferences of the respondents. In the parametric model, in addition to endogenous variables, the socio-economic characteristics of the respondents, there must be appropriate exogenous variables, while in fact there exist only few theories that provide guidance on appropriate exogenous variables.

Factors Affecting People's Willingness to Pay for Improved Water Quality

Running a binary logit regression, Table 6 shows the factors that affect decision to pay for water quality improvement in handicraft villages.

Table 6. Factors affecting WTP, Bac Ninh province

Independent Variable	**DC1**		**DC2**	
	Coefficient	Standard Error	Coefficient	Standard Error
Age	-0.011	0.008	-0.03	0.07
Edu	0.37	0.108	0.118	0.102
Gender	0.175	0.175	0.018	0.168
HHsize	0.01	0.056	0.125**	0.055
HH type	0.518***	0.183	0.18	0.176
HHapr	-0.403***	0.133	-0.362**	0.128

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HH trade-off	0.189	0.190	-0.289	0.181
Income	0.581***	0.105	0.281***	0.083
WaS	2.124***	0.360	1.036**	0.343
Village	-0.930***	0.124	-0.510***	0.116
BID1	-0.004***	0.000		
BID2			-0.003***	0.000
BID2mh				
Constant	3.912***	0.713	2.625***	0.660
N	997		997	
-2log likehood	1015.564		1102.650	
Pseudo R^2	0.336		0.241	
LR chi2	279.180		192.094	
Prob>chi2	0.000		0.000	

***, **, * significant at 1%, 5% and 10% probability levels, respectively

DC1 and DC2 models have quite similar conclusions on the factors affecting the people's willingness to pay for water quality improvement. Households with high incomes and using tap water are more likely to say "yes" to the given bid. This result is similar to the findings of Quy Van Khuc (2013) which revealed that the use of water from natural sources would induce higher probability to pay for improved water quality. Households using tap water are aware of hazards from using natural water source in the current polluted water condition so they tend to support water quality improvement programs. The positive coefficient of household income confirms the microeconomic theory (e.g., Dale, *et al*. 1990 and Bateman, *et al.* 2002) that households with higher income would have greater WTP for water quality improvement program. On the other hand, HH type in DC1 model is positive and significant. To reiterate, handicraft producers are aware of the negative impact of their production activities on water sources. So they are willing to pay for environmental and water quality improvement. HH size in DC2 has a positive and statistically significant coefficient, implying that households with more members would be more likely to say "yes" to the given bid.

Access to communication program (HH apr), village and bid variables have negative and highly statistically significant coefficients. This means respondents who have heard about pollution problems tend to support water improvement programs. The negative coefficient of village, as found in the results from the study of Nasreen, *et al.* (2014), shows that households living in high risk zones tend to respond "yes". Households that are closer to the two contaminated Cau and Ngu Huyen Khe rivers would be more likely to support the projects to

improve their water quality. As expected, the bids have a significant negative effect on the probability that a household is willing to pay either the first or the second bid amount, that is, the higher the bid, the lower the probability that a respondent agrees to pay). This conforms to the conclusions of Jin, *et al. (*2016) and Nasreen, *et al.* (2014).

V. CONCLUSIONS AND RECOMENDATION

The results of the study revealed that people in the study areas were aware of the worsening state of water pollution. Nearly all of the locals (96.8%) agree that water pollution is the most serious problem and waste from handicraft production was the main reason. A vast majority (95.9%) believed that environmental pollution has affected household health, production, consumption, and economic performance.

On average, according to DC1 model, about 64.7% of the households are willing to pay to improve the quality of the water environment. Double-bounded dichotomous-choice allows to avoid some bias of CVM. The WTP of households at Bac Ninh's handicraft villages in the DC1 and DC2 models was estimated to be 275,816 VND/year and 355,821 VND/year, respectively. The total potential funding that could be collected from households at Bac Ninh's handicraft in the DC1 model and DC2 model is 93.86 million VNĐ/year (4.05 million USD/year) and 121.09 million VNĐ/year (5.23 million USD/year), respectively. The total real funding calculated based on the number of people who are willing to pay at these villages in DC1 model and DC2 model is 60.73 million VNĐ/year (2.62 million USD/year) and 102.686 million VNĐ/year (4.43 million USD/year), respectively.

Households who have high income, living near contaminated water source, using tap water and households who are production facilities, and respondents with larger family tend to agree with the given bid. Households who have never heard about environmental pollution and households who get a higher bid are more likely to refuse the presented bid.

Solutions to raise people's awareness through communication channels and social organizations; to increase income associated with environmental protection policies. To construct wastewater treatment plants; To encourage the relocation of production establishments to industrial parks and industrial complexes; The financial policy focuses on producing facilities that cause pollution, putting regulations on collection, payment and sanctions in case of not declaring and paying fees into village conventions; To promulgate circulars, and bylaws to concretize and simplify regulations and policies of the Government, Ministry of Natural Resources and Environment, and People's Committee of Northern Province Ninh.

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