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Estimation of Varying Parameters Model in Contingent Valuation: Case Study in a Wetland Conservation

Tatsuo Suwa

Many contingent valuation (CV) studies have been implemented to estimate willingness to pay (WTP) for a non-market good over the last two decades. Most of these studies are based on a linear in income model which is introduced to CV study by Hanemann (1984) due to a convenience of calculation. This paper compares a linear in income model which denotes constant marginal utility and a varying parameters model (VPM) with inconstant marginal utility, using data from a questionnaire about wetland conservation in the Hokkaido area. The estimation results show that a VPM fits better than the linear in income model. The results suggest that the higher income group has lower marginal utility of income. Thus, this paper derives an implication, which asserts the necessity of considering decreasing marginal utility of income that is neglected in Hanemann's basic model. Moreover, the estimation results demonstrate that income level affects not the value of marginal utility of environmental quality, but the value of marginal utility of income. Accordingly, differences in each household's WTP seem to be caused mainly by the dispersion of income level.

JEL Classification Numbers: C35, Q26
Key Words: Contingent Valuation, Income Effect, Varying Parameters Model

1. Introduction

Many contingent valuation (CV) studies have been implemented to evaluate the willingness to pay (WTP) for an environmental quality or amenity over the last two decades. A number of these studied are based on the binary choice random utility model (RUM) which uses a questionnaire introduced by Hanemann (1984)[1)]

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His achievement is to introduce a binary choice RUM into the valuation of an environmental qualitative change using questionnaire data. In the study, he makes use of a linear in income model. To date, following Hanemann's model a number of studies have relied on a utility function which holds the marginal utility of income constant, because of its convenience of calculation, the difficulty of calculating a nonlinear model and the unavailability of income data. However, constant marginal utility is regarded as a restrictive or particular case (*e.g*. Gorman form) in most of the microeconomics literature. Therefore, it seems to be necessary for analysts to consider a changeable marginal utility of income which depends on income level or other factors.

The purpose of this paper is to investigate which model is best suited to describe the preference of a household plausibly in a binary choice RUM[2]. The comparison between a "linear" in income model and a "nonlinear" in income model, is attempted using questionnaire data associated with environmental quality change. In this study, Bekanbeushi marsh in Akkeshi town located in eastern area in Hokkaido prefecture is chosen as a field site. It is registered as the Ramsar Convention site, because it holds a variety of migratory birds. A questionnaire survey is implemented in Akkeshi town where household are asked whether they would accept a hypothetical plan for conservation of the marsh in exchange for a certain amount of tax using double-bounded question method.

Using data collected from the field site, parameters are estimated using linear and nonlinear in income models. In this study, a varying (income) parameters model (VPM) which uses slope dummy variables for income level is employed instead of nonlinear in income model, due to a lack of continuous income data. The result shows that one of the VPM has the best conformity of the concerned models, when judged using Akaike information criteria. Also, the estimation results roughly indicate that the lower income group has a higher marginal utility of income, though an exception exists. Moreover, the results also seem to show that income level affects only the marginal utility of income and does not affect the marginal utility of environmental quality. This suggests that novel and interesting implication meaning that, contrary to common perception, preference for environmental quality is basically identical across households and difference of WTP for an environmental quality change depends mainly on the variety of marginal utility of income.

In the next section, the basic economic model used in this study is introduced. The third section describes the details of the field site and the contents

1) Hanemann derives willingness to pay (WTP) and willingness to accept for recreation hunting in Wisconsin from purchase or sale behavior of hunting licenses using questionnaire data.

2) Herriges and Kling (1999) compare a linear model and nonlinear model in a "nested logit model".

of the questionnaire implemented there. Section four shows the estimation results derived using the questionnaire data. Lastly, the conclusion of this study is given in section 5.

2. Model

Many CV studies have been made use of the linear in income model to derive the WTP for a non-market good. To develop a model, this paper begins with the following general indirect utility function for household i with an error term which is not specified to a linear form just as in Hanemann's model[3)]

$$U_i = V(q,\ y_i;\ a_i) + \varepsilon_i \tag{1}$$

V is the deterministic part of the utility function, while ε is a random term with zero mean representing unobservable factors. y_i and q are income and environmental quality respectively. a_i indicates attributes such as occupation and residence area. In this model, V is assumed basically to have an identical form across households, but the form is affected by attributes.

Price is suppressed since only cross section data is used and the price level is identical for all household. It is assumed that V is continuous in q and y and each first derivative has the following sign.

$$\frac{\partial V}{\partial q} \geq 0,\ \ \frac{\partial V}{\partial y} \geq 0$$

Given this utility function, an environmental quality improvement from q_0 to q_1 in exchange for expenditure, $e.\ g,\ a$ tax increase or donation for it is supposed. This improvement causes the following change in utility for household i.

$$\triangle U_i = U_{i1} - U_{i0} = \{V(q_1, y_i; a_i) - V(q_0, y_i - T; a_i)\} + \{\varepsilon_{i1} - \varepsilon_{i0}\}$$

where T is the tax increase.

Invoking the "mean value theorem"[4)], this equation is rewritlen as follows.

$$\triangle U_i = \left.\frac{\partial V(q, y_i\ ; a_i)}{\partial q}\right|_{q=q^*} \cdot \triangle q + \left.\frac{\partial V(q, y_i\ ; a_i)}{\partial y}\right|_{y_i = y_i^*} \cdot \triangle y_i + \eta_i \tag{2}$$

where $q^* \in [q_0, q_1]$, $y_i^* \in [y_i - T, y_i]$, $\triangle q = q_1 - q_0$ and $\eta_i = \varepsilon_{i1} - \varepsilon_{i0}$.

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3) Hanemann (1984) assumes the following linear utility function. $U = \alpha q(a_i) + \beta y_i + \varepsilon_i$

4) Simon and Blume [12] explain the "mean value theorem" in chapter 30.

This paper considers this general form of the change in utility when WTP is estimated by binary choice RUM, while most current studies seem to assume a linear form. Then, this paper attempts to make clear which specification for $\partial V(q, y_i; a_i)/\partial q$ and $\partial V(q, y_i; a_i)/\partial y$ is more suitable. The main concern of this paper is to confirm whether $\partial V(q, y_i; a_i)/\partial y$ should be specified using a linear in income form or not. Details of the specification are discussed in the section 4.

3. Field Site and Questionnaire

Bekanbeushi marsh located in the eastern area of Hokkaido prefecture, is chosen as the field site for this study. A questionnaire survey associated with the protection of the marsh was carried out in December 2000. This section describes the detail of the field site and the questionnaire implemented there.

3.1 Field site

Akkeshi town is located in Kushiro district of eastern Hokkaido (see Figure 1). Similar to other towns in this district, the key industries of this town are diary farming and fisheries. Akkeshi town contains Bekanbeushi marsh and Lake Akkeshi in the center of its territory. As shown in Figure 2, Lake Akkeshi is located in the lower course of the marsh. Most of the area in Bekanbeushi Marsh and Lake Akkeshi has been registered as a Ramsar site[5] since1993, because it holds a variety of migratory birds[6].

Bekanbeushi River, which runs through Bekanbeushi Marsh, is a popular spot for recreational fishing and canoeing in the local area, due to its rich wildlife and beautiful scenery. From Spring to Autumn, a considerable number of people visit the marsh for recreation.

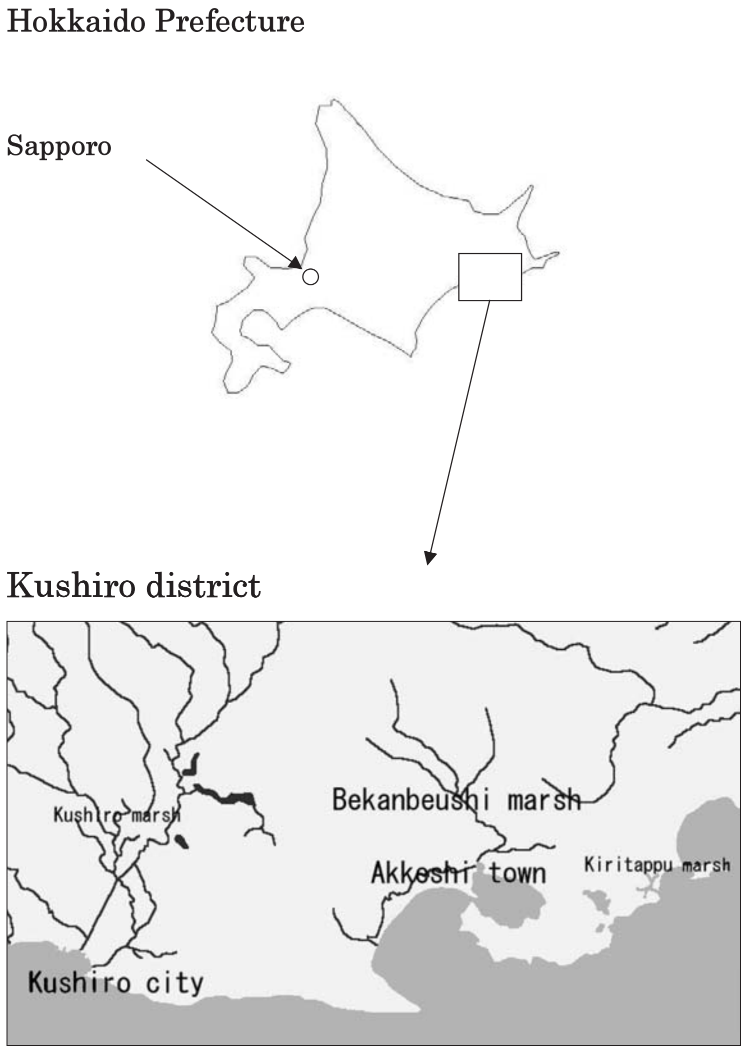
Fish farming of Oyster and short-neck cram has been carried on for a hundred years in Lake Akkeshi. Oyster farming in Lake Akkeshi seems to be an especially symbolic industry[7] of the town, although all fishermen in the town do not engage in fish farming in Lake Akkeshi. Recent study (for example, Barbiar *et.al*. (1997)) shows that wetland generally functions as a filter of water and smoothes water quality changes caused by heavy rain or other factors. These functions of wetland result in positive effects for fishery and other production. Affected by such studies, some of the fishermen in Akkeshi town

5) Nishino (2000) described a history of protection of the marsh. Ramsar convention on wetland concluded in 1971, requires signatory countries to report protection or management plan for a domestic wetland registered as Ramsar site. See Matthews (1993).

6) Wildlife, world heritage or natural monuments may contain "existence value". See Turner et.al. (1994), chapter 8.

7) For this reason, "Akkeshi oyster festival" has been held in this town annually in October.

Figure 1. Location of Akkeshi Town



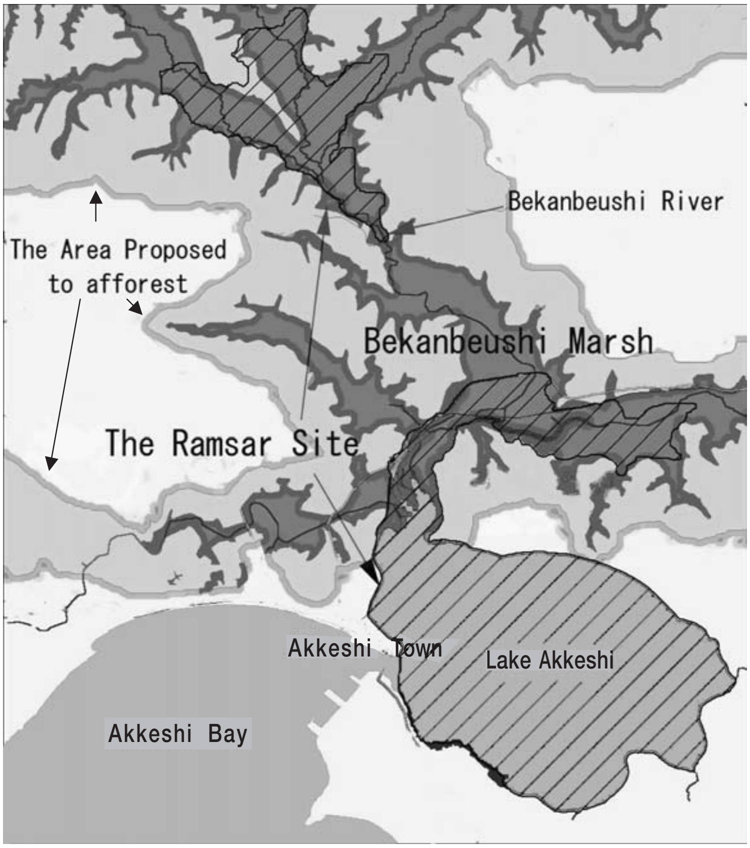
believe that fish farming in Lake Akkeshi is influenced by Bekanbeushi marsh and its surrounding forest, although the relation between these has not been made clear scientifically yet. As Nishino (2000) introduced, fishermen in Akkeshi have afforested the bald area around the marsh since 1988 to enhance the quality of the upper stream environment, though the scale of this activity is very small.

Considering these facts, Bekanbeushi marsh seems to be connected deeply with the lives of the residents of Akkeshi town.

3.2 Questionnaire

In December 2000, a questionnaire was implemented using a home-visit distribution and collection survey in Akkeshi town. In the questionnaire, households were proposed a hypothetical plan that suggested afforesting a certain area around Bekanbeushi marsh with broadleaf trees to conserve and improve the quality of the marsh, just as described in Figure 2 . The hypothetical plan also suggested arranging an appropriate number of rangers to watch around the marsh and regulate excessive human impacts. It is explained the respondent would be required to share a certain amount of the cost for the proposed plan as an annual tax. Thus, lastly respondents were asked whether they approved of the plan with the size of the offered annual tax or not. Respondent was asked with two different annual taxes using the double-bounded question which Hanemann *el.al* . (1991) has shown to nave a higher statistical significance for the estimated parameter. That is, if the respondents did not approve of first offered tax, then next they are asked with a lower tax in a

Figure 2 . Map of the Field Site



Note: The area described with a diagonal line is registered under the Ramsar convention.
Note: The area proposed to afforest surrounding Bekanbeush marsh is the area in which afforestation is planned as a hypothetical policy in the questionnaire.

Table 1. Offered Tax

Lower Offer	First Offer	Upper Offer	The Number of Samples
500	1000	2000	25
1000	2000	5000	24
2000	5000	10000	25
5000	10000	20000	27

Table 2. Distribution of Household: The Sample and Population

Area	Oboro	Oota	Bekan	Sinryu	Honchou	Tokotan	Total
Population	309 (6.88%)	359 (8.00%)	89 (1.99%)	2035 (45.40%)	1486 (33.15%)	204 (4.55%)	4482
Sample	13 (12.87%)	13 (12.87%)	2 (1.98%)	34 (33.66%)	33 (32.67%)	4 (3.96%)	101

Note: The number of household of each area is data at September 2000.

Note: Small numbers in parentheses are share in the total.

follow-up question and *vice versa*. 4 types of offers were utilized as shown in Table 1. Respondents also answered questions concerning individual attributes, such as address, income, and the number of household members, occupation and an experience with recreation in Bekanbeushi marsh.

143 respondents in Akkeshi town answered the questionnaire. However, some samples missed an item of relevant information. These were dropped and the remaining 101 samples were applied to the analysis. Akkeshi town is roughly divided into 6 resident areas (Oboro, Oota, Bekan, Sinryu, Honchou, Tokotan). Therefore, samples were chosen to balance the ratio of the resident area, because the dominant occupation is different across resident areas. Table 2 shows resident distributions of the sample and the population[8]. It shows that the sample seems to be competent with regard to ratios of each resident area. The questionnaire is summarized in Table 3. In the table, "Distance" shows the distance to the marsh of each household. "Recreation" is a dummy variable that shows experience of recreation in the marsh. "Fishery" is also a dummy which indicates that the respondent engages in fishery. "Income Group" classifies household annual income into 4 groups. In the questionnaire, respondents which of six income groups they belong to (group 1 (less than 1 (million yen)), group 2 (1 ~ 5 (million yen)), group 3 (5 ~10 (million yen)), group 4 (10~15 (million yen)), group 5 (15~20 (million yen)), group 6 (more than 20 (million yen))). In this survey no respondent belongs to

8) The population data is quoted from "Statistics of Akkeshi Town" (2001).

Table 3. Data Summary

Variables	Mean	St-Dev	Max	Min
Distance (km)	10.278	6.507	30.2	5.8
Household Member (head)	3.228	1.640	7	1
Recreation	27.723%			
Fishery	13.861%			
Income Group 1	4.95%			
Income Group 2	55.45%			
Income Group 3	31.68%			
Income Group 4	7.92%			
Number of observation			101	

Note: Mean Values for dummy variables are percentages of total number of respondents.

group 6 (more than yen 20 (million yen)). Group 5 has few corresponding households, so it is integrated into group 4. Thus, a new classification of four groups is used where: group 1 (less than 1 (million yen)), group 2 (1 ~ 5 (million yen)), group 3 (5 ~10 (million yen)), group 4 (more than 10 (million yen)) as shown in Table 3.

4. Estimation and Result

The utility function (1) described in section 2 is applied to an analysis of the responses to the questionnaire. In this study households are assumed to have the following utility function depending on data collected by the questionnaire.

$$U_i = V(q, y_i; a_i) + \varepsilon_i$$

where q represents the quality of the marsh, a consists of household attributes, as described in table 3, excluding income group dummies. The hypothetical environmental quality change causes a change in utility, which is divided into two parts as in equation (2) in section 2. In this paper, the two deterministic parts of the change in utility are assumed to have the following forms.

$$\left.\frac{\partial V(q, y_i; a_i)}{\partial q}\right|_{q=q^*} \cdot \triangle q = \alpha_0 + \alpha_1 \cdot REC_i + \alpha_2 \cdot FISH_i + \alpha_3 \cdot DIST_i + \alpha_4 \cdot HM_i + \alpha_5 D2_i + \alpha_6 \cdot D3_i + \alpha_7 \cdot D4_i \quad (3)$$

where *REC* is the Recreation dummy, FISH is the Fishery dummy, HM is the number of Household Members, DIST is Distance, and D 2, D 3 and D 4 are dummy variables corresponding to the income group 2, 3 and 4, respectively.

$$\left.\frac{\partial V(q, y_i; a_i)}{\partial y}\right|_{y=y^*} \cdot \triangle y = (\beta_1 + \beta_2 \cdot D2_i + \beta_3 \cdot D3_i + \beta_4 \cdot D4_i) \cdot T_i \tag{4}$$

Specification (3) implies that the marginal utility of environmental quality level may depend on possibly influential household's attributes and income level group. Reflecting the main concern of this study, specification (4) applies VPM[9], in which using slope dummy variables, the marginal utility of income varies between belonging income groups. This method is feasible in this study, since a discrete variable for the income level of different households is available. Each income group is assumed to have a different value for $\partial V(q, y_i^*; a)/\partial y$. As shown in specification (4), $\triangle y$ corresponds to TAX in the study.

4. 1 Estimation of parameters

Using specifications (3) and (4), the following model of utility difference is established to estimate each parameter.

$$\triangle U_i = \alpha_0 + \alpha_1 \cdot REC_i + \alpha_2 \cdot FISH_i + \alpha_3 \cdot DIST_i + \alpha_4 \cdot HM_i + \alpha_5 D2_i + \alpha_6 \cdot D3_i + \alpha_7 \cdot D4_i + (\beta_1 + \beta_2 \cdot D2_i + \beta_3 \cdot D3_i + \beta_4 \cdot D4_i) \cdot T_i + \eta_i$$

where η_i is assumed to be *logistically distributed.*

However, to avoid multicollinearity[10], the following two models are estimated instead.

$$\triangle U_i = \alpha_0 + \alpha_1 \cdot REC_i + \alpha_2 \cdot FISH_i + \alpha_3 \cdot DIST_i + \alpha_4 HM_i + \alpha_5 \cdot D2_i + \alpha_6 \cdot D3_i + \alpha_7 \cdot D4_i + \beta_1 \cdot T_i + \eta_i \tag{5}$$

$$\triangle U_i = \alpha_0 + \alpha_1 \cdot REC_i + \alpha_2 \cdot FISH_i + \alpha_3 \cdot DIST_i + \alpha_4 HM_i + (\beta_1 + \beta_2 \cdot D2_i + \beta_3 \cdot D3_i + \beta_4 \cdot D4_i) \cdot T_i + \eta_i \tag{6}$$

According to Hanemann *el.al*. (1991) [6], the log likelihood function for a double-bounded model using the answer of a follow-up question is expressed as follows.

$$LogL = \sum_{i=1}^{n} [YY_i \cdot \log(F(T_{ui}; a_i)) + YN_i \cdot \log(F(T_i; a_i) - F(T_{ui}; a_i))$$

9) Haab and McConnel (2003) describes the varying parameters model used to consider the nonlinearity of income in a random utility model in chapter 2. They also propose a utility function which is log linear in income. But such a model is impossible to apply, because continuous income data, which the model needs, are not available in this study.

10) $D2$, $D3$ and $D4$ are highly correlated to $D3 \cdot T$, $D3 \cdot T$ and $D4 \cdot T$, respectively.

$$NY_i \cdot \log\left(F(T_{li}; a_i) - F(T_i; a_i)\right) + NN_i \cdot \log\left(1 - F(T_{li}; a_i)\right)$$

where YY, YN, NY, NN are dummy variables corresponding to the answers to the first and second (follow-up) offer of a respondent.

F () is *c.d.f* of a *logistic* distribution[11], T is the first tax level offered and T_u, T_l are the second tax levels, (follow-up) upper and lower amounts of tax respectively, offered The parameters are estimated so as to maximize the log likelihood function[12].

The results of the estimation are shown in the rows of Model (5) and Model (6) in table 4 . They indicate that all attributes except REC are not significant. Therefore, excluding attributes out of significance level (FISH, DIST, HM), the following two modified models are estimated as a second step.

$$\triangle U_i = \alpha_0 + \alpha_1 \cdot REC_i + \alpha_5 \cdot D2_i + \alpha_6 \cdot D3_i + \alpha_7 \cdot D4_i + \beta_1 \cdot T_i + \eta_i \tag{7}$$

$$\triangle U_i = \alpha_0 + \alpha_1 \cdot REC_i + (\beta_1 + \beta_2 \cdot D2_i + \beta_3 \cdot D3_i + \beta_4 \cdot D4_i) T_i + \eta_i \tag{8}$$

Obviously, Model (7) and Model (8) correspond to Model (5) and Model (6) respectively. Lastly, the following simple linear model without income dummies is estimated to compare the other models.

$$\triangle U_i = \alpha_0 + \alpha_1 \cdot REC_i + \beta_1 \cdot T_i + \eta_i \tag{9}$$

The estimation results of these models are shown also in Table 4 . The results indicate that model (8) seems to fit better than the linear in income models (model (5), model (7), model (9), judging from the value of the Akaike information criteria (AIC) statistics[13].
This fact implies that VPM seems to be comparatively superior to the linear in income model.

Furthermore, the table shows that most of the coefficients of the slope dummy variables (*i.e.* β) are significant, while all of the coefficients for intercept dummies of income group are not. This implies that income level affects not $\partial V / \partial q$, but $\partial V / \partial y$. That is, the value of environmental conservation for each household does not depend on income level. Only an experience of recreation affects the value. This seems interesting, because this inference is in-

11) For example, $F(T_{ui}; a_i) = 1/(1 + \exp(-\triangle V_i(T_{ui}; a_i)))$.

12) Software, "Ox, version 3.20" is used for estimation of parameters.

13) According to Maddala [9] chapter 11, AIC is defined as, $-2\log L/n + 2k/n$ (n and k are the number of observations and variables, respectively).

Table 4. Results of the Estimations

Parameters		Model (5)	Model (6)	Model (7)	Model (8)	Model (9)
α_0	(CONST)	-0.145	0.405	0.0831	0.794**	0.711**
		(-0.194)	(0.770)	(0.121)	(3.270)	(2.997)
α_1	(REC)	0.733*	0.731*	0.696*	0.698*	0.702*
		(1.738)	(1.724)	(1.671)	(1.664)	(1.679)
α_2	(FISH)	0.0323	0.150	-	-	-
		(0.0587)	(0.278)			
α_3	(DIST)	0.0913	0.102	-	-	-
		(0.757)	(0.888)			
α_4	(HM)	0.00890	0.00402	-	-	-
		(0.312)	(0.144)			
α_5	(D 2)	0.361	-	0.485	-	-
		(0.483)		(0.665)		
α_6	(D 3)	0.730	-	0.942	-	-
		(0.906)		(1.248)		
α_7	(D 4)	0.814	-	1.101	-	-
		(0.810)		(1.120)		
β_1	(T)	-0.000383**	-0.00158**	-0.000381**	-0.00166**	-0.000372**
		(-8.661)	(-2.804)	(-8.678)	(-2.932)	(-8.737)
β_2	(D 2 *T)	-	0.00121**	-	0.00129**	-
			(2.158)		(2.286)	
β_3	(D 3 *T)	-	0.00123**	-	0.00132**	-
			(2.182)		(2.337)	
β_4	(D 4 *T)	-	0.00111*	-	0.00122**-	-
			(1.921)		(2.200)	
	log L	-153.67	-149.59	-154.01	-150.08	-155.36
	AIC	3.221	3.140	3.169	3.091	3.136

Note: Small numbers in parentheses are t-ratios.

Note: Small "**" ("*") indicates significance at the 5% (10%) level.

consistent with a natural intuition that a rich household cares more about environmental quality more than a poor household.

4.2 Estimation of WTP

WTP of Akkeshi households for the hypothetical afforestation plan is calculated using parameters of Model (8) in Table 4, which is the best on the grounds of AIC. WTP in respect to "median" is calculated to satisfy the following equation, because n_i has a logistic distribution.

$$\frac{1}{1+\exp(-\triangle V_i)}=0.5 \tag{10}$$

where $\triangle V_i = \alpha_0 + \alpha_1 \cdot REC_i + (\beta_1 + \beta_2 \cdot D2_i + \beta_3 \cdot D3_i + \beta_4 \cdot D4_i)\, WTP_i \cdot$

Transforming equation (10), Median WTP for each household can be calculated as follows.

$$\text{Median WTP}_i = \frac{\alpha_0 + \alpha_1 REC_i}{\beta_1 + \beta_2 \cdot D2_i + \beta_3 \cdot D3_i + \beta_4 \cdot D4_i}$$

The denominator of this equation represents the marginal utility of income which differs among income groups. Therefore means of the median WTP for the 4 different income groups are determined depending on marginal utility of income. These values are presented in Table 5 . Table 5 indicates that the median WTP varies between income groups to some degree. It is worth mentioning that WTP of income group 3 is higher than WTP of income group 2 and WTP of income group 2 is higher than that of income group 1 , reflecting a decreasing marginal utility of income. This is likely to be consistent with a basic assumption of microeconomics. Exceptionally, WTP of income group 4 is lower than that of groups 2 and 3. This exception is likely to be caused by the average number of household members in each income group. Table 6 notes the average number of household member in each income group. It indicates that households belonging to the income group 4 have a larger number of household members than the others. This fact implies that they cannot afford to accept the offered tax increase, due to a substantially higher level of expenditure caused by the larger number of household member[14]. It seems that they are not as rich as income level suggests. For this reason the value of their marginal utility of income is not so small. This problem may be resolved by utilizing an "equivalence scale"[15] for child or retired elder members in the household. To take an accurate measurement of the wealth level of a household, total household income should be divided by the weighted number of household

Table 5. WTP of Each Income Group

	Income Group 1	Income Group 2	Income Group 3	Income Group 4
WTP	¥562	¥2640	¥2969	¥2200

Table 6. Average Number of Household Member in Each Income Group

	Income Group 1	Income Group 2	Income Group 3	Income Group 4
Number	1.800	3.625	2.946	4.500

14) An alternative income group depending on per head household income is tried. But it does not bring any significant estimates for β.

15) Equivalence scale indicates a ratio of the cost of a child to the one of an adult. Deaton notes it in chapter 4 .

member. This treatment is left to future work.

5. Concluding Remarks

The results of the questionnaire survey in Akkeshi town show that a model with varying marginal utility of income has a better fit than the linear in income models. This result implies that when valuing non-market goods using a random utility model, the currently used linear in income model is not necessarily appropriate and that the incorporation of income effect into model seems to be essential to understand the preferences of concerned households correctly.

Also, this study indicates that the marginal utility of income in each income group is estimated roughly as the lower income group has a higher marginal utility of income and the resulting WTP of the lower group is smaller than the WTP of the higher groups. But this tendency does not dominate the highest income group, due probably to the larger number of household members. This fact means suggests the models in this paper do not perfectly express the situations of every household (*e.g.* level of richness). Developing the model to represent the situations of households more precisely, remains for future work.

Moreover, the estimation results for parameters associated with income dummy variables shows that income level does not affect the marginal utility of environmental quality. This suggests that preference for the environmental quality is identical across income levels. This implies a novel and interesting possibility as the variance of WTP for environmental quality change depends mainly on differences in marginal utility of income caused by a variety of income levels, not the diversity of household preferences for environmental quality.

Doctoral Student, Hokkaido University

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