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Abstract

This analysis investigates determinants of preference discontinuity and tests whether accounting for information on preference discontinuity improves efficiency of willingness-to-pay estimates. Using two follow-up questions, 10.4 % of respondents are identified as potentially expressing discontinuous preferences. The probability to preference discontinuity increases with young age, female gender, higher income, non-coastal residence, and having filled out the questionnaire in a hurry. The performance of error component multinomial logit model improves when accounting for information on preference discontinuity either by introducing a scale parameter in the model or by eliminating attributes perceived less important by respondents. The scale model suggests equal variances of choices between respondent groups having continuous and discontinuous preferences. The elimination approach increases the efficiency of WTP estimates for attributes. The effect of more informed analysis on magnitudes of WTP estimates remains small.

Keywords: water quality; willingness to pay; choice experiment; discontinuous preferences; error component multinomial logit

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1 Introduction

The use of choice experiment (CE) method has drastically increased in the elicitation of public preferences for environmental goods and in the estimation of welfare changes associated to environmental problems. The core of a CE survey is a series of choice tasks. A task presents alternative environmental goods to respondents. Environmental goods, such as improvements in water quality resulting from alternative management options, are described in terms of the characteristics (attributes) reflecting different dimensions of the good, following Lancaster's characteristics theory of value (Bennett and Blamey, 2001; Lancaster, 1966). According to neoclassical economic theory, the respondent maximizes her utility in a choice task by choosing the alternative that yields the highest utility.

The underlying assumption of the utility maximising behaviour is that the individual makes rational choices over a given set of alternatives. One of the axioms of rationality is the continuity of preferences (Mas-Colell et al., 1995). In the CE context, continuous preference ordering means that the respondent's choice among alternatives in choice task bases on consideration of *all* characteristics of a good and on comparison of losses in one attribute to gains in another attribute. The standard analysis of choice data implicitly postulates continuity of preferences and attribute processing strategies other than accounting for *all* attributes when comparing alternatives do not receive attention. Because real data sets contain many attribute processing strategies, there is a growing interest on incorporating information on attribute non-attendance in the analysis (see, e.g. Campbell et al., 2008; Campbell et al. 2011; Hensher and Greene, 2010; Hensher et al., 2012; Meyerhoff and Liebe, 2009).

Previous research has found evidence of the deviations from the standard economic behaviour. A subset of attributes have been ignored (see, e.g., Carlsson et al., 2010; DeShazo and Fermo, 2002; Hensher et al., 2005; Hensher et al., 2007; Swait, 2001) or the preference ordering has been lexicographic (e.g., Rekola, 2003; Rulleau and Dachary-Bernard, 2012; Saelensminde, 2006; Spash and Hanley, 1995). Preference discontinuity may stem from actual preference structure when some attributes are not behaviourally relevant for the respondent. Another potential reasons are the use of a simplifying strategy to manage the cognitive burden in a complex choice situation (e.g., Campbell et al., 2008; Hensher et al., 2005; Saelensminde, 2006) and ethical reasoning, for instance, some respondents refuse to trade money and environmental attributes (Rekola, 2003; Spash and Hanley, 1995).

Previous studies suggest that not taking into account the differences in respondents' preference orderings may lead to a failure in preference revelation and the associated willingness-to-pay estimates. The direction of bias, though, has been case-dependent. Ignoring non-standard attribute processing strategies has resulted in an increase (Cantillo et al., 2006; Hensher et al., 2005) or a decrease (DeShazo and Fermo, 2004) in WTP estimates. Besides the magnitude of WTP, accounting for discontinuous preferences affects the distribution of WTP (Hensher et al., 2007) and the efficiency of WTP estimates (e.g., Campbell et al., 2008).

Attribute non-attendance can be studied in the choice task level (see Meyerhoff and Liebe, 2009) or in the serial level assuming the same processing strategy through all tasks. Information on attribute processing strategies can be built into estimation of choice data either parametrically by adjusting the model for unexplained variance or by eliminating discontinuous responses from the analysis (Hensher et al., 2005; Hensher, 2006b; Hensher et al., 2007; Saelensminde, 2006). Moreover, preference discontinuity can be inferred from the data without utilizing the information stated by respondents (Hensher et al., 2012; Hess and Hensher, 2010). This paper focuses on the stated serial non-attendance and addresses water quality improvement in the Gulf of Finland resulting from an implementation of a nutrient reduction policy. The attributes refer to water quality characteristics, such as water clarity, fish stocks, and occurrences of algae, and a payment (price of improvement in water quality) for the respondent. Eutrophication of the Gulf of Finland involving diverse consequences applies well for studying the effect of accounting for attribute processing strategies on monetary estimates. First, it is plausible to assume that people differ in their perceptions of the most important consequences of eutrophication and only a subset of attributes is of behavioural relevance to respondents. Second, gathering the WTP estimates that are as efficient as possible is valuable for the policymaking.

The contribution of this paper is two-fold. Firstly, it analyzes the incidence of discontinuous preferences and examines, with the logistic regression, the determinants of expressing discontinuous preferences. Secondly, it estimates the WTP for water quality improvement in the Gulf of Finland with the Error Component Multinomial Logit (ECM) model and provides information on the precision of the WTP estimation in the presence of preference discontinuity. It tests the effect of two alternative treatments of preference discontinuity on the estimates: 1) introducing a scale parameter in the model (see Campbell et al., 2008), and 2) eliminating attributes which a respondent perceived less important (see Hensher et al., 2005). Finally, the paper compares the resulting WTP estimates with the estimates from the standard choice modelling approach and discusses the implications of considering deviations from standard economic theory for choice modelling analysis and environmental decision-making.

The paper is structured as follows. Section 2 reviews empirical applications on discontinuous preferences and attribute processing strategies and section 3 presents the theoretical framework. Section 4 describes empirical data, section 5 discusses the results, and section 6 concludes.

2 Empirical applications on discontinuous preferences

Besides the standard rational utility-maximising behaviour, people may behave in two alternative ways when facing a choice task: passive-bounded rationality and rationally adaptive behaviour. These differ in terms of whether individuals *intend* to attend to all attributes or not. A passive-bounded rationality model is based on assumption that individuals *do* attend to all attributes but levels of error (or, inconsistent choices) may appear. In a rationally adaptive model, individuals are aware of their limited cognition and attend to information in the choice task such that they minimize the cost (or maximize the benefit) of evaluating information. (de Palma et al., 1994; DeShazo and Fermo, 2004)

Concerning passive-bounded rationality, inconsistent choices refer to the violation of the transitivity axiom of the neoclassical consumer theory. According to empirical evidence, choice inconsistency may be induced by the characteristics of the choice task and of the respondent. These include the complexity of the choice task measured in terms of the number of choice situations, alternatives, attributes, and attributes levels and their range (Caussade et al., 2005; DeShazo and Fermo, 2002; Hensher, 2006a; Swait and Adamowicz, 2001), and socio-demographic characteristics, e.g. lower education (Saelensminde, 2001, 2002).

The idea of rationally adaptive behaviour is that respondents may place boundaries on a choice task in order to assist in the choice making and to manage the cognitive burden, and thus, they express the seemingly lexicographic preference orderings. In addition to simplifying behaviour owing to a difficult choice task, discontinuous preferences may result from real lexicographic preferences or actual non-lexicographic preferences when the ranges of attribute levels are too wide. The latter is supported by the evidence on the existence of lexicographic choices in relatively easy choice tasks having a small number of attributes that are *a priori* known by the respondent (Mazzotta and Opaluch, 1995; Saelensminde, 2006).

Many reasons for discontinuous preferences have been investigated (see, e.g., Payne et al., 1992; Rosenberger et al., 2003). Saelensminde (2006) reports that less educated respondents are more likely to choose lexicographically for simplifying reasons, as well as the respondents who expressed having difficulty in concentrating. In addition, time pressure and cognitive load are found to be determinants of simplifying (Diederich, 2003; Drolet and Luce, 2004). Discontinuous preferences may be caused by respondents' unwillingness to trade money for environment (i.e., ethical reasoning) or their uncertainty about the meaning of a good (Spash and Hanley, 1995), and young age and high income (Hensher et al., 2007).

When analysing the stated attribute non-attendance, the discontinuous preference structure can be identified either by exploring answers to follow-up questions (Spash and Hanley, 1995; Rosenberger et al., 2003; Hensher et al., 2005; Hensher et al., 2007; Campbell et al., 2008) or by identifying actual choice behaviour (Lockwood, 1999; McIntosh and Ryan, 2002). Once identified, one approach to treat preference discontinuity is to eliminate those observations from the analysis. However, Lancsar and Louviere (2006) caution that eliminating responses from the data that are identified by the researcher as being irrational may actually lead to unintentional removal of valid preferences. Another approach is to consider preference discontinuity parametrically by adjusting the statistical model. This can be done by specifying a decision strategy as an explicit factor in the model (Campbell et al., 2008) or using the latent class model to divide respondents into groups attending to particular sets of attributes (Campbell et al. 2011). Moreover, information on attribute processing strategy can be considered stochastically by introducing it as heterogeneity in the mean of a random parameter

(Hensher et al., 2007). These model specifications show the effect of different preference structures on the preference parameters and the associated willingness-to-pay estimates. Yet another way is to introduce scale parameter in the error component logit model to reveal differences in variance (that is, heterogeneity in the error term) of those who ignored a subset of attributes and those who attended to all attributes (Campbell et al., 2008). This reveals whether or not the choices of respondents having discontinuous preferences are “noisier”.

Previous studies suggest that the bias on marginal WTP estimates (that is, the WTP estimates for attributes) can be significant when ignoring the differences the respondents' preference orderings. The implications for the magnitude and the direction of WTP estimates are mixed. Accounting for discontinuous preferences has resulted in both the increase in the marginal WTP estimates (DeShazo and Fermo, 2004) and the decrease in the marginal WTP estimates (Cantillo et al., 2006; Hensher et al., 2005), as well as the decrease and the increase depending on which attribute the respondent prefers on lexicographic grounds (Saelensminde, 2006). Moreover, statistically insignificant differences in the WTP estimates between individuals having continuous or discontinuous preferences have been empirically evidenced (Rulleau and Dachary-Bernard, 2012).

3 Theoretical framework and econometric specification

The choice experiment (CE) method is based on the neoclassical consumer theory according to which an individual aims at maximization of her utility when choosing among alternative goods, such as the water quality in the Gulf of Finland. The goods are described following the attribute theory of value (Lancaster, 1966) according to which the value of the particular good is the sum of its characteristics. The choice experiment is consistent with the random utility theory. For *j* alternatives, individual *n* compares the utilities U_{nj} associated with alternatives. The additive utility function U_{nj} consists of a deterministic part V_{nj} and the error term ε_{nj} :

$$U_{nj} = V_{nj} + \varepsilon_{nj}, \tag{1}$$

where, for individual *n* and alternative *j*, V_{nj} is the observable part of utility that is explained by the attributes of the good (and the respondent-specific and questionnaire-specific characteristics), and ε_{nj} is the unobserved part of utility. The individual *n* chooses the alternative *j* if:

$$U_j \geq U_q, \forall q, j \neq q, \tag{2}$$

that is, the utility derived from the alternative *j* exceeds the utility from the alternative *q*. By assumptions of the consumer theory, well-behaving preferences are in accordance with the continuity axiom (Mas-Colell et al., 1995). In the CE context, continuity means that respondent's choice is based on the trade-off between the alternatives in terms of consideration of all attributes. However, instead of considering all attributes fully, some respondents may be indifferent for changes in some attributes and ignore them.

This study analyzes the data with the Error Components Multinomial Logit model belonging to a family of Mixed Logit models following Train (2009). In the probabilistic choice model, the utility function U_{nj} for individual *n* of alternative *j* is specified as:

$$U_{nj} = V_{nj} + \varepsilon_{nj} = \alpha_j + \sum_k \beta_k x_{jkn} + \varepsilon_{nj} + \mu_n E_{nj} \tag{3}$$

where α_j is the alternative-specific constant (one for the business-as-usual option for identification purposes), β_k is the coefficient for attribute *k* and x_{jkn} is the value of attribute *k* for alternative *j*, and the error term ε_{nj}, which is independent of other terms in the equation. The error terms in utility functions are independent and identically distributed (IID) with type I extreme value distribution. The error term defines the stochastic proportion of utility with the error component E_{nj}, and μ_n is a random term with zero mean. The error component E_{nj} refers to alternative-specific random individual effects. In our model specification, it accounts for substitution (correlation) patterns between the policy options. The specification of the error component E_{nj} allows heteroscedasticity in its variance:

$$Var[E_{nj}] = \exp(\lambda h_n), \tag{4}$$

where h_n is the variable (individual and choice invariant) that produces heterogeneity in the variances of the error components, and λ is the associated scale parameter. The scale parameter measures the effect of preference ordering on the variance of the WTP.

In the random utility framework, the utility-maximizing choice of the alternative *j* of the respondent *n* can only be determined up to probability. The type I extreme value distribution of the error term leads to the following expression of the probability to choose the alternative *j*:

$$\Pr(choice = j) = \int \frac{\exp(\beta_j' \mathbf{x}_{nj}) + \mu_n(\exp(\lambda h_n))E_{nj}}{\sum_{j=1}^{J_i} \exp(\beta_j' \mathbf{x}_{nq}) + \mu_n(\exp(\lambda h_n))E_{nj}}. \tag{5}$$

For the selected water quality improvement, the expected WTP (or consumer surplus) of individual *n* follows the standard Hanemann (1982) utility difference expression, which assumes the constant marginal utility of income over the population:

$$E(WTP_n) = -1/\beta_p \left[\ln\left(\sum \exp(V^1)\right) - \ln\left(\sum \exp(V^0)\right)\right] \tag{6}$$

where β_p is the parameter estimate of the cost, V^1 is the utility evaluated in the policy case, defined as changes in attribute levels relative to the business-as-usual case, V^0.

4 Data: water quality improvement in the Gulf of Finland

The data collection by mail took place in July 2006 (see a description in Kosenius, 2010). This analysis bases on a random sampling of 1000 Finns of ages 18-80 that resulted in 307 received answers. The 12-page questionnaire began with questions about the respondent's connections to the Gulf of Finland, perception of current water quality both in general and in terms of attributes and opinions of the scenario elements. The scenario was the base for a series of six discrete choice questions. Respondents also answered several attitudinal questions about the topic, socio-demographic questions, and questions related to completing the questionnaire.

In choice tasks, respondents chose between three alternative water quality states of the Gulf of Finland in the year 2030 that result from alternative nutrient reduction policies. The attributes describing the states (table 1) were water clarity, number of coarse (not preferred) fish species (*Cyprinids*), health of a perennial macro algae species bladder wrack (*Fucus vesiculosus*) that provides an important reproduction environment for fish and invertebrates, and abundance of mass occurrences of potentially toxic blue-green algae. All water quality attributes, except for the blue-green algae blooms, had three qualitatively described levels, while the price attribute had seven levels. The payment vehicle was an additional annual tax for each Finnish household for a period of 20 years to be invested in new measures to combat eutrophication.

Table 1. Attributes and levels.

Attribute	**Description**	**Attribute levels**		
Tax for household (PRICE)	Tax for household once a year for 20 years (€)	0, 5, 30, 70, 150, 350, 500		
Water clarity (WAT)	Visibility of sea bottom (at 1m depth)	Clearly visible	Hardly visible	Not at all visible
Numbers of Cyprinids (FISH)	Numbers of so-called coarse fish (*Cyprinids*)	Small	Large	Very large
Bladder wrack (BLW)	State of bladder wrack population	Good	A bit weakened	Weakened a lot
Blue-green algae bloom (BGA)	Mass occurrences of blue-green algae during summer	1–4 days	5–21 days	22–60 days

Note: Questionnaire version with uncertain policy options included an attribute "Likelihood of achieving the state" with levels 60%, 80%, and 100% (for BAU option). Questionnaire version with uncertain BAU option had no additional attributes.

CHOICE SITUATION 1

	AGREEMENT A	AGREEMENT B	NO AGREEMENT (C)
TAX FOR THE HOUSEHOLD	€70 / year	€30 / year	€0 / year
SEA BOTTOM CAN BE SEEN	clearly	hardly	not at all
NUMBERS OF CYPRINIDS	small	rather large	large
BLADDER WRACK IS	good	a bit weakened	weakened a lot
BLUE-GREEN ALGAE OCCURS	1–4 days	5–21 days	22–60 days
The best alternative is … **(please check one)** →	**A** ☐	**B** ☐	**C** ☐

Figure 1. Example of choice task in base questionnaire version.

In choice tasks (figure 1), the alternatives were labelled as “Agreement A,” “Agreement B,” and “No Agreement (C)”. The “No Agreement” option referred to the business-as-usual (BAU) situation described by worst levels of water quality attributes and no additional payment (€0). The policy options differed in terms of ecological states resulting from policy implementations and the amount of payment ranging from €5 to €500. The states in the policy options were combinations of the two highest attribute levels. Thus, the choice of the policy option, no matter which one, yielded at least the modest improvement in all four water quality attributes and the considerable improvement in some attribute(s). The experimental design for the choice experiment was conducted with the balanced overlap procedure in Sawtooth Software program. The design of 36 choice tasks was divided into six blocks of six tasks.

Three questionnaire versions differed in terms of certainty (or likelihood) of achieving outcomes, i.e., the states of the Gulf of Finland. The base version defined all outcomes (both of the policy options and of the BAU option) to come true without explicitly specifying the level of certainty. In a policy uncertainty version, the outcomes of the policy options (A and B) were uncertain, representing the success of the policy as perceived by the experts. The likelihood for the policy to result in the described state was either 60% or 80%. If the policy failed, the outcome of the BAU option would result. In the BAU uncertainty version, the likelihood of the lowest water quality becoming true would be 80%, and thus, with the likelihood of 20%, the resulting water quality would be, in terms of all attributes, comparable to at least the middle level. In the Gulf of Finland, the uncertain development of the state in the absence of new policies may be due to the uncertain nature of the marine ecosystem processes and internal loading that counteracts the implemented nutrient reduction measures (Pitkänen et al., 2001).

After all choice tasks, respondents answered two follow-up questions related their attribute processing strategies and the perceived relative importance of attributes: “When choosing the preferred alternative, did you consider every part of each alternative” (Question 11), and “Were some characteristics more important than others; if yes, which one(s)” (Question 12). According to the plan, the question 11 was for identification of preference discontinuity, but it turned out to have confused respondents who may not have understood the question with the intended meaning. The identification thus requires more support for which the question 12 serves best. Related to the wording of this question, three aspects are important to note: 1) lack of the information about the ranking of attributes considered by the respondent, 2) inability to define the extent of the consideration of attributes, and 3) the assumption that the respondent followed the same attribute processing strategy through all choice sets. If the respondent answered “No” to question 11 and, in question 12, provided one or more attributes being relatively more important than other attributes, this was considered as a *potential* indication of discontinuous preferences.

5 Results

The ultimate reason for non-market valuation is to provide an aggregated measure of welfare change associated to an environmental problem, and the sample’s representativeness of the population is crucial. Table 2 shows the descriptive statistics. The t-tests do not suggest statistically significant differences with respect to age, income, or any other socio-economic characteristics between the sample and the population. However, according to the Pearson chi squared tests, the sample had fewer respondents with dependent children in household and more summer cottage owners than the Finnish population on average. Recognizing that the t-test may not be especially powerful in this setting, this analysis not heading to aggregate welfare measures nevertheless proceeds under the assumption that the sample is sufficiently representative of the general population.

Table 2. Descriptive statistics of sample and corresponding population data.

	Sample average	**Finnish average[a]**	**T-test stat.**	**Chi Sq. stat.**
Sample size	307	5255580		
Socio-demographic characteristics				
Age (OLD)	48.32	45.88	-0.61	
Dependent children in the household (% with dep.ch.) (DEPCH)	17.26	41.18	0.39	71.74 ***
Income (net, thousand € / year) (HINC)	33.71	31.0	-0.59	
Coastal residence (% living in coastal municipalities) (COA)	26.06	23.47	-0.04	1.16
Vacation home ownership (% of owners on the coast of the Gulf of Finland) (VAC)	3.91	2.44	-0.03	3.66 *

[a] Population data are from Statistics Finland (2006).
***(*) refers to the 1(10)% significance level.

Out of 307 respondents, 159 (51.8%) stated that some attributes were more important than others (question 12). Table 3 presents the shares of these respondents by attribute and by questionnaire version. In all versions together, 26.4% of respondents considered the tax attribute more important than other attributes, followed by blue-green algae (10.7%), water clarity (6.8%), bladder wrack (6.2%), and the fish attribute (0.7%). The certainty attribute was not perceived very important. Moreover, differences in uncertainty treatments did not affect people’s perceptions on relative importance of marine and monetary attributes, and the pooled data is analyzed further.

Table 3. Shares of respondents who stated the relative importance of one/more attribute(s) (n=159) in all data and by questionnaire version

	All data		**Questionnaire versions**		
			Base	**Pol-Unc**	**Bau-Unc**
Attribute	**Number**	**%**	**%**	**%**	**%**
Tax	81	26.4	24.5	28.9	25.7
Certainty	3	NA	NA	2.9	0.0
Water	21	6.8	6.9	6.7	6.9
Fish	2	0.7	1.0	0.0	1.0
Bladder wrack	19	6.2	7.8	5.8	5.0
Blue-green algae	33	10.7	11.8	10.6	10.0

Note: All differences between questionnaire versions are statistically insignificant in 5% level.

5.1 Determinants of preference discontinuity

Based on questions 11 and 12, 32 (10.4 %) respondents were identified as potentially having discontinuous preferences. It should be noted here that this share does not reflect the occurrence of preference discontinuity in the whole data set, because possibly some respondents having discontinuous preferences were eliminated among the protester answers identified prior this analysis. Table 4 shows the statistically significant determinants of preference discontinuity modelled with the logistic regression. The dependent dummy variable DISCONT equals one for the respondent with discontinuous preferences. After testing of several determinants, the following factors appeared to explain well preference discontinuity, although the explanatory power (R^2) of the model remained low, 0.05. The probability of expressing discontinuous preferences decreases with age older than average (OLD), being male (GENDER), and increases with an increase in household income (INCOME). In addition, the probability decreases if the respondent lives in a municipality situated on the coast of the Gulf of Finland (COAST) and increases if the respondent stated that she was in a hurry while filling out the questionnaire (HURRY). The former result is probably linked to respondent's knowledge on the issue, indicating that respondents who are familiar with the marine environment less likely simplify the choice task. The latter implies the existence of rationally adaptive behaviour in the sample, meaning some respondents revealed seemingly lexicographic preferences when trying to manage time constraints.

Table 4. Logistic regression of discontinuous preferences.

Variable	**Coefficient**	***St.Error***	**Sign.**
Constant	-2.287	*0.122*	***
OLD: 1=older than average	-0.335	*0.099*	***
GENDER: 1=male	-0.522	*0.103*	***
INCOME	0.013	*0.002*	***
COAST	-0.836	*0.135*	***
HURRY	0.609	*0.099*	***

R^2=0.05, ***) significant at 1% level

5.2 Implications for WTP estimation

Three Error Component Multinomial Logit models were run with Limdep 9.0 Nlogit 4.0 to estimate the WTPs for the attributes and for the selected improvement in water quality. First, the Standard Model assumed that all respondents behave according to compensatory preference ordering. Second, the Scale Model included the scale parameter for discontinuous preferences. Third, the Elimination Model was estimated excluding the attributes that the respondent perceived less important[2]. The qualitative water quality attributes (WAT, FISH, BLW, and BGA) were effects-coded, and only the best levels of each attribute were included in the analysis for identification purposes. The price attribute (TAX) was treated as continuous.

Table 5 reports the results. All three models have rather good and similar fits measured by the Pseudo R^2 (0.357–0.361) and the number of correct predictions (50.5–51.0%). The Scale Model provides considerable improvement over the Standard Model according to the LL ratio test: the chi squared test statistic (12.02) is above the critical limit for one degree of freedom (3.84). Due to different data sets, the formal test of the Elimination Model vs. the Standard Model is not appropriate, but the comparison of the log likelihood values of the models shows that the former outperforms the latter.

All water quality variables (WAT, FISH, BLW, and BGA) and the price attribute (TAX) are of expected signs and mostly statistically significant. The probability to choose a particular alternative increases with increase in water quality and with decrease in price. The negative alternative-specific constant BAU implies the tendency to choose, on average in the sample, the policy alternative instead of the BAU alternative, revealing people's support for nutrient reduction of the Gulf of Finland. The positive sign of the error component E implies the heterogeneity in intensities of the respondents to choose the policy option. In the Scale Model, the scale parameter with a value below one (one being a value for the normalized reference group of continuous preferences) indicates the larger variance for the group of discontinuous preferences. However, statistical insignificance of the parameter does not support the rejection of the null hypothesis of equal variances across the groups having standard versus discontinuous preferences. This means weak evidence of the passive-bounded rationality, that is, more consistent choices of respondents having continuous preferences.

[2] Here we do not eliminate irrational responses (as criticized by Lancsar and Louviere (2006)) but instead, we eliminate only those attributes which were perceived as less important by the respondent. We utilize the coding of -888 for these attributes, and the program then adjusts the model such that, for the eliminated attributes, coefficients are set to zero (Greene, 2007).

Table 5. Results from the standard model, model with a scale parameter for discontinuous preferences, and the model excluding less important attributes.

Variable / Model	Standard Model			Scale Model			Elimination Model		
	Coef	*S.E.*	Sign	Coef	*S.E.*	Sign	Coef	*S.E.*	Sign
TAX	-0,010	*0,000*	***	-0,010	*0,000*	***	-0,012	*0,000*	***
Water clarity WAT	0,262	*0,073*	***	0,262	*0,074*	***	0,347	*0,081*	***
Coarse Fish FISH	0,168	*0,078*	**	0,168	*0,079*	**	0,158	*0,096*	
Bladder wrack BLW	0,050	*0,075*		0,055	*0,075*		0,091	*0,092*	
Blue-green algae BGA	0,111	*0,064*	*	0,112	*0,064*	*	0,176	*0,069*	**
BAU	-3,964	*0,360*	***	-4,230	*0,413*	***	-4,186	*0,391*	***
Error component E	3,180	*0,252*	***	3,482	*0,390*	***	3,511	*0,367*	***
Scale: Discontinuity	-			0,064	*0,261*		-		
No of observations	1687			1687			1687		
No of respondents	307			307			307		
Log likelihood	-1191.75			-1185.74			-1184.80		
Log likelihood (0)	-1853.36			-1853.36			-1853.36		
Pseudo R	0,357			0,360			0,361		
Correct predictions	51,0 %			50,9 %			50,5 %		

***(**)* significant at 1(5)10% level

Table 6 presents the estimates for an increase in water quality attributes from the BAU level to the highest qualitative level, for the alternative-specific constant that refers to WTP not associated to attributes, and for the scenario referring to improvement in all water quality characteristics from the BAU level to the highest qualitative level. By assumption, the sample non-respondents had a zero WTP. The WTP estimates (euro/household/year) and the corresponding standard errors were calculated by the delta method.

Table 6. Marginal WTP estimates for discrete changes in attributes and for selected scenario, associated 95% confidence intervals (in parentheses) and percentual changes in range of 95% c.i.s compared to Standard Model.

MODEL	Standard Model		Scale Model			Elimination Model		
	WTP (Range of 95% c.i.)	*St.Error*	WTP (Range of 95% c.i.)	*St.Error*	Change (%)	WTP (Range of 95% c.i.)	*St.Error*	Change (%)
ATTRIBUTES								
Water clarity	18,34	*5,01*	18,26	*5,04*		20,57	*4,77*	
	(19.64)		**(19.74)**		**0.49**	**(18.68)**		**-4.90**
Fish	11,79	*5,35*	11,75	*5,35*		9,36	*5,66*	
	(20.96)		**(20.96)**		**-0.02**	**(22.19)**		**5.85**
Bladder wrack	3,53	*5,19*	3,84	*5,17*		5,43	*5,42*	
	(20.35)		**(20.27)**		**-0.38**	**(21.24)**		**4.39**
Blue green algae	7,80	*4,41*	7,78	*4,40*		10,46	*4,03*	
	(17.30)		**(17.26)**		**-0.28**	**(15.81)**		**-8.65**
Alternative specific constant	277,48	*24,11*	294,90	*26,66*		248,38	*21,56*	
	(94.50)		**(104.52)**		**10.61**	**(84.53)**		**-10.54**
SCENARIO	318,94	*22,04*	336,52	*24,86*		294,20	*20,70*	
	(86.41)		**(97.46)**		**12.79**	**(81.14)**		**-6.11**

Note: Lower and upper bounds of 95% c.i.s are calculated: WTP-/+ 1.96*St.error. Range=upper bound-lower bound.

Measured in WTP amounts, the relative ranking of water quality attributes is common for the Standard Model and the Scale Model: water clarity followed by the fish, blue green algae, and bladder wrack attributes. Instead, in the Elimination Model accounting for preference discontinuity more sharply, the blue green algae attribute is more important than the fish attribute, and consistently, the Elimination Model produces higher WTP estimates for the blue green algae attribute (€10.46) than for the fish attribute (€9.36). This reflects the relative popularity of the blue green algae attribute (see table 3) that is corrected by the Elimination Model which does not give any weight to less important attributes.

The range of the 95% confidence interval measures the efficiency of WTP estimates. The percentual change in the range of confidence intervals, the Standard Model being the reference, compares the efficiencies between estimates from different models. Accounting for preference discontinuity does not result in considerable changes in the efficiencies of the WTP estimates for attributes, since all changes are smaller than 10%. When looking at the scenario level, the annual household WTP estimates for the improvement in the water quality characteristics to the highest qualitative level are 318.94€ from the Standard Model, 336.52€ from the Scale Model, and 294.20€ from the Elimination Model. The 95% confidence range of the Scale Model is less than 13% larger than that of the Standard Model, indicating loss in efficiency of WTP estimates when accounting for preference discontinuity. The Elimination Model reports the opposite result: the decrease in the range of the 95 % confidence interval is 6 %, implying a small improvement in efficiency.

6 Conclusions

This paper investigated the occurrence and the causes of discontinuous preferences in the choice experiment context and tested the impact of accounting for preference discontinuity on the monetary estimates of the benefits from the water quality improvement in the Gulf of Finland with three Error Component Multinomial Logit models. The fact that a tenth of the respondents to this study revealed potentially discontinuous preferences strongly encourages viewing preference discontinuity endogenously in the discrete choice analysis. It also emphasizes the importance of testing alternative ways to account for discontinuous preferences to avoid biases in the WTP estimation.

The logistic regression results implied that picking up the subset of attributes instead of considering each part of the choice task might have been a simplifying strategy for some respondents to manage the cognitive burden due to time constraints. The socio-economic determinants of discontinuous preferences (young age and high income) were in accordance with previous findings. Further investigation of causes for perceived importance of particular water quality attributes (water clarity, number of coarse fish, state of bladder wrack, and occurrences of blue-green algae) and the price attribute would give insight into the relevance of particular attributes for respondents.

Contrary to previous studies, respondents having discontinuous preferences did not seem to have a larger variance in preferences. This, however, does not necessarily indicate similar choice consistency between respondents having continuous and discontinuous preferences, because of a strict identification procedure of discontinuous preference structure, and an originally small sample.

The results are encouraging from the viewpoint of using WTP estimates as a guide in environmental policymaking. A more informed analysis did not lead to considerable changes in the magnitudes of WTP estimates. An important result was that the effect of accounting for information of preference discontinuity on the efficiency of WTP estimates was less than 10 %. It is naturally up to the decision maker to consider this level of change remarkable or not. However, it should be noted that when applying the environmental cost-benefit analysis, the cost estimates available are not fully precise either.

Preference discontinuity is an indisputable part of non-market valuation with stated preferences techniques. An important result for valuation research is that accounting for this deviation from the standard economic behaviour in the analysis can improve the efficiency of monetary estimates. Although in this analysis the elimination strategy served as the best approach to treat discontinuous preferences, it must be applied with caution because it artificially alters the data set. In order to be able to generalize the conclusions drawn on the most appropriate modelling strategy for preference discontinuity, analysis of larger data sets would be valuable, as well as analysis of multiple data sets and accounting for inferred attribute non-attendance as an alternative way to treat preference discontinuity.

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