The Beijer Institute of Ecological Economics

DISCUSSION PAPER

Beijer Discussion Paper Series No. 212

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Therese Lindahl and Tore Söderqvist. 2008.

THE BEIJER INSTITUTE OF ECOLOGICAL ECONOMICS

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Who Wants to Save the Baltic Sea when the Success is Uncertain?*

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Abstract

Recent research shows that the Baltic Sea has experienced an ecosystem change and is now in a degraded state with respect to water quality. Moreover, it is uncertain whether this deterioration is reversible. The purpose of the study is to analyze how people respond to this type of uncertainty when asked if they would be willing to pay something in order to make it possible to carry out an abatement program. The purpose of the program is to improve the marine water quality of the Baltic Sea but the program is only successful with a certain probability. Our mixed results could have important policy implications as the answer to the question depends very much on how we ask.

Key words; Irreversibility, scope test, uncertainty, valuation, convex-concave resources, Baltic Sea,

*We are grateful to Magnus Johannesson, Tore Ellingsen and Martin Dufwenberg for valuable comments. This work was partly carried out in the research program Sustainable Coastal Zone Management (SUCOZOMA), funded by the Foundation for Strategic Environmental Research (MISTRA).

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1 Introduction

Today there exists an extensive and increasing amount of empirical evidence that many ecosystems are characterized by complex dynamics, for example, by growth functions for biomasses that are not concave but rather convex-concave. This means that they can have multiple stable states with separate domains of attraction. A typical feature of such ecosystems is that they can undergo sudden changes and flip from one stable state to another. (Steffen et al., 2004, Resilience Alliance, 2005). These characteristics are due to the existence of positive feedbacks in the systems and they also imply that a new state can become highly robust, sometimes the change may even be irreversible. (Carpenter 2003, Shaeffer et al. 2001) Such positive feedbacks have been found in both terrestrial and aquatic systems, on local as well as on global levels. For example, due to intense fishing a coral reef can flip from a coral-dominated to an algae-dominated state (Nyström et al. 2001, Hughes 1994)). Similarly for grasslands, due to intense grazing grasslands can flip from a grass-dominated to woody shrubs-dominated state or may even become a dry desert (Perrings and Walker 1997, Janssen et al 2004).

The importance of this feature for optimal management of ecosystems is increasingly being recognized (see for example the overview and specific economic analyses by Dasgupta and Mäler (2003), Brock and Starrett (2003), Mäler, Xepapadeas and de Zeeuw (2003), Crépin (2003)). However, as far as we understand little, or no effort, has been made to analyze the implications of this feature for the provision of public goods, such as environmental improvement.

Consider for example the following scenario. Suppose there has been a shift in an ecosystem to a degraded state and that the new state is very robust. In fact, the degradation is reversible only with a certain probability. Simultaneously, there is a discussion whether or not efforts should be made to try to restore this ecosystem. To elicit people's preferences towards such a potential improvement one may rely on a stated preferences method (Freeman, 2003), for example the Contingent Valuation Method (CVM), a method widely used for eliciting willingness to pay for public goods. Within such a setting, the validity of the responses will very much depend on how well people understand the nature of this type of uncertainty (potential irreversibility).

In light of this, the overall aim of this paper is to analyze people's preferences with respect to potential irreversibility of environmental degradation. Based on the increasing amount of empirical evidence that we can expect such problems to appear more frequently, we believe it is important to analyze how people respond to this type of uncertainty, not the least for future design and interpretation of CVM studies involving this kind of uncertain provision of public goods.

Our case study is the highly vulnerable and disturbed ecosystem of the Baltic Sea. Recent research shows that it is uncertain whether a healthy state of the Baltic Sea can be recovered; there is a risk that the ecosystem cannot be restored, regardless of measures taken (Swedish Environmental Advisory Council, 2005).

We follow the stated preference approach and design a questionnaire where randomly selected individuals are asked whether they would be willing to pay something for a program with the purpose of improving environmental quality where the program is characterized by success uncertainty, meaning that the program will have the intended effect only with a certain probability.

We use two procedures for introducing this type of uncertainty; a between-sample design where each respondent is being informed about one out of five success probabilities, and a within-sample design where each respondent is asked to provide an answer to each of the five success probabilities.

Our design resembles tests of scope sensitivity of the CVM. These tests try to find out whether CVM results show sensitivity to variations in quantity and quality of the good being valued. Scope sensitivity is a hot topic and has been the focus of much debate.[1] Ever since the distinguished NOAA panel (Arrow et al. 1993) recommended, inter alia, scope tests, numerous such tests have been conducted, using both between-sample and within-sample approaches with mixed results.[2] However, as

[1] For example, it was debated when the State Government of Alaska filed suits against Exxon Corporation claiming damages following the grounding of Exxon Valdez in 1989. The claims were based on CVM estimates of the costs incurred as a result of the oil-spill. (For overviews and discussions of the CVM see Portney, 1994; Hanemann, 1994; Diamond and Hausman, 1994; Carson et al., 2001; Freeman, 2003.)

[2] See for example Carson's (1997) survey of 30 CVM studies where he concludes that only in a handful of them were respondents not sensitive to scope. These studies were mainly within-sample tests. For between-sample tests, see for example the meta analysis by Smith and Osborne (1996), or the study by Svedsäter (2000). Whereas the former found sensitivity to scope the latter did not.

far as we understand this is the first study to test sensitivity to scope in relation to the probability of program success.

We want to remind the reader, that although the approach is similar, this is not a CVM study in itself. We will not be concerned with estimating total willingness to pay for a potential increase in water quality. Instead, to fit the purpose of the paper, the main focus will be given to analyzing the effect of uncertainty on peoples responses.

We proceed as follows. The next section describes the ecological background and our data. In Section 3 we present the empirical model used. The results are presented in Section 4 and a discussion and some concluding remarks are given in Section 5.

2 Empirical background

2.1 The problem

There exists empirical evidence that there are ecosystems that have been degraded to the point where it is uncertain whether a healthy state can be recovered at all. One such ecosystem is the Baltic Sea. With the moderate age of 10-15,000 years, the Baltic Sea is the youngest sea on the planet. Its brackish water creates unsuitable or at least stressful conditions for most marine species. The resulting relatively low biodiversity makes the Baltic Sea ecosystems extra vulnerable. At the same time the Baltic Sea is the catchment area of 85 million people and due to pollutants and nutrients from land-based activities, such as sewage treatment, industrial and municipal waste there is a lot of stress on this ecosystem. (Resilience Alliance, 2005)

According to recent findings, the Baltic Sea has at least two stable ecological states. One state (the former state) is associated with clear water, submerged vegetation and preferred fish species. Due to overloads of nutrients, the amount of dissolved oxygen in the water has decreased, and because the water turnover is in the order of 20 years (due to the low inflow of water from the North Sea) the high level of phosphorus and nitrogen stays within the system. As a result there has been a shift in the ecosystem to another steady state, an eutrophic state associated with toxic algae blooms, turbid water, oxygen deficiency and less preferred fish species. Today the Baltic Sea is one of the most threatened marine ecosystems on the planet; no less than 88% of the biotopes found in the Baltic Sea are listed as endangered. (Resilience Alliance, 2005)

The ministers of environment within the Helsinki Commission (HELCOM) agreed in 1988 on an action program to reduce the loads of nutrients by half by the year of 1995 (Swedish Cabinet Bill 1990/91:90). This goal has not been achieved and additional efforts have been suggested and to some extent carried out. (Swedish EPA 2003).

However, recent research shows that it is uncertain whether the change in the ecosystem is reversible; there is a risk that the Baltic Sea cannot be restored regardless of measures taken. (Swedish Environmental Advisory Council, 2005)

2.2 Data

A mail survey was designed for collecting data about people's behavior when asked whether they would be willing to pay something (i.e. an amount > 0) for a hypothetical abatement program with the purpose to improve the marine water quality of the Stockholm Archipelago, a part of the Baltic Sea. The respondents were informed that the program would only be successful with a certain probability. The questionnaire was received by in total of 4,500 randomly selected adult inhabitants in the county where the archipelago is situated (Stockholm County) and in one adjacent county (Uppsala County) and the overall response rate was about 57 percent.

We are especially interested in analyzing response behavior with respect to the probability of a successful program and the sampled individuals were randomly grouped into six sub-samples. Five of these were used for a between-sample design, where each individual faced one of the following five success probabilities; $\{0.1, 0.25, 0.5, 0.75, 0.9\}$. The remaining sub-sample was used for a within-sample design, where each individual faced all five success probabilities and was asked to give an answer to each of them.

Both designs included a description of the abatement program. The program involved measures in the agricultural and municipal sectors that with some X-percent probability would result in water quality improvement by a 1-meter increase in the average water transparency. If launched, the program would entail price increases for products produced by these sectors, including increases in municipal water tariffs. The ongoing deterioration of the water quality would continue if the program turns out not to be successful. The scenarios for the between-sample and within-sample designs are found in the Appendix.

The main question to be analyzed was formulated as follows. *Would you accept or not accept to pay something in terms of increased expenses in order to make it possible to carry out this abatement program?* Three mutually exclusive response alternatives followed: *I would definitely accept*, *I would probably accept* and *I would not accept*. These alternatives are abbreviated by *definitely, probably* and *no* below.

In the between-sample design, the respondent were also asked to specify the maximum amount in SEK he or she would be willing to pay per month and we will also make use of this information in our analysis. Some descriptive statistics are given in Table 1.[3]

Table 1. Descriptive Statistics

variable	N	mean	stdv.	min	max
resident	2353	0.067	0.250	0	1
cottage	2348	0.193	0.395	0	1
visit	2347	0.572	0.495	0	1
income	2268	12 175	6 910	0	100 000
female	2387	0.548	0.498	0	1
age	2381	43.733	15.103	16	78
U. County	2312	0.131	0.338	0	1
definitely	3131	0.469	0.499	0	1
probably	3131	0.414	0.493	0	1
no	3131	0.117	0.321	0	1

The respondents are between 16 and 78 years with an average of about 44 years. About 55 percent are female, 7 percent are residents in the archipelago, 19 percent report to own a cottage in the archipelago or that someone in their family own a cottage, and 13 percent live in Uppsala County. The average personal monthly income (including unemployment benefits, child support, student loans etc. and after tax) is

[3] Each respondent answers five questions in the within-sample design and these answers are in Table 1 treated as different observations. The dummy variables were coded as follows; 1 for residence in the archipelago, 0 otherwise; 1 for visitor in the archipelago, 0 otherwise; 1 for cottage in the archipelago, 0 otherwise; 1 for female respondent, 0 otherwise; 1 for residence in Uppsala County, 0 otherwise. The variable age is given in years and income is net personal income per month in SEK.

about SEK 12,200. About 47 percent answered *definitely*, 41 percent answered *probably* and about 12 percent answered *no* to the question.

3 Empirical strategy

For the main question, each respondent is facing three alternatives. The discrete choice of each individual partly depends on unobservable factors specific to the individual. Motivated by three response alternatives, where *no*, *probably* and *definitely* are coded 0, 1 and 2 respectively, we use an ordered discrete choice model (Zavoina and McElvey, 1975) to analyze the data. The model is built around a latent regression, where the underlying response model is given by equation (1).

$$y_i^* = \boldsymbol{\beta}'\mathbf{x}_i + \boldsymbol{\epsilon}_i \tag{1}$$

Note that y_i^* is not observable, but what we do observe from respondents' answers is

$$\begin{array}{ll} y_i = 0 & \text{if } y_i^* \leq 0; \\ y_i = 1 & \text{if } 0 < y_i^* \leq \mu; \\ y_i = 2 & \text{if } \mu < y_i^*. \end{array} \tag{2}$$

The parameter μ is an unknown threshold parameter to be estimated along with a coefficient vector, $\boldsymbol{\beta}$. In this model, a positive (negative) coefficient means that the probability of acceptance increases (decreases). The error term $\boldsymbol{\epsilon}$ is assumed to be normally distributed with mean 0 and variance 1. Thus we have that

$$\begin{array}{l} \Pr(y_i = 0) = \Pr(\boldsymbol{\beta}'\mathbf{x}_i + \boldsymbol{\epsilon}_i \leq 0) = 1 - \Phi(\boldsymbol{\beta}'\mathbf{x}_i); \\ \Pr(y_i = 1) = \Pr(0 < \boldsymbol{\beta}'\mathbf{x}_i + \boldsymbol{\epsilon}_i \leq \mu) = \Phi(\mu - \boldsymbol{\beta}'\mathbf{x}_i) - \Phi(-\boldsymbol{\beta}'\mathbf{x}_i); \\ \Pr(y_i = 2) = \Pr(\mu < \boldsymbol{\beta}'\mathbf{x}_i + \boldsymbol{\epsilon}_i) = 1 - \Phi(\mu - \boldsymbol{\beta}'\mathbf{x}_i). \end{array} \tag{3}$$

where Φ is the standard normal cumulative distribution function. The probability that a person falls into any one of these categories depends on a vector of decision variables $\mathbf{x}_i$. Estimation is done by maximum likelihood.

The within-sample design is analyzed by a random effects ordered probit model which is built around the regression

$$y_{ip}^{*} = \boldsymbol{\beta}'\mathbf{x}_{ip}+\boldsymbol{\epsilon}_{ip}+\mathbf{u}_{p} \tag{4}$$

where p denotes success probability. The term $\mathbf{u}_p$ is assumed to be normally distributed with mean 0 and variance σ^2. The random effects model is appropriate because of the panel nature of the within-sample design, where each respondent answers five questions. If we were to use the same method as for the between-sample design it could lead to biased estimates.

To test the influence of the uncertainty on willingess to pay (WTP) we use a simple linear regression model.

The decisions variables included in $\mathbf{x}_i$ (and $\mathbf{x}_{ip}$) are, besides dummies for the probabilities of reversibility (denoted as d10, d25, d50, d75 and d90), income, age, a variable measuring the respondents' assessment of the importance of clean and clear water in the archipelago in a scale from 0 (no importance) till 100 (crucial importance) (WQA) and dummy variables for female, residency in Uppsala County (U. County) and visit to the archipelago during the summer. Note that by using a dummy variable for visit we also include most residents and those who own a cottage in the archipelago.

Conventional economic theory suggests that more of a desired market good lead to more consumer utility. As a result it is logically assumed that consumers should be sensitive to changes in size and scope of environmental goods and services. Based on this we test the following hypothesis, which is also the main hypothesis.

Hypothesis 1 *For both designs, we expect a positive and significant relationship between the probability of program success and the probability to answer definitely.*

If increased water quality is a normal good (has a positive income elasticity) we also expect the following to be true.

Hypothesis 2 *For both designs, we expect a positive and significant relationship between income and the probability to answer definitely.*

For a consistency check we test the following.

Hypothesis 3 *For both designs, we expect a positive and significant relationship between the importance of water quality and the probability to answer definitely.*

Finally, we expect value to diminish with distance.

Hypothesis 4 *For both designs we expect a positive and significant relationship between visit and the probability to answer definitely and a negative significant relationship between U. County and the probability to answer definitely.*

4 Results

The overall response behavior is reported in Table 2, where respondents who answered *definitely, probably* and *no* are described by the decision variables. In line with hypotheses 2 - 4, respondents tend to answer *definitely* rather than *probably* and *no* if she; has a cottage in the archipelago and/or made a visit to the archipelago, has a higher income, assess the importance of clean and clear water as high and lives in Stockholm County rather than Uppsala County.

Table 2. Overall response behavior

	Definitely		*Probably*		*No*	
variable	mean	stdv.	mean	stdv.	mean	stdv.
resident	0.074	0.262	0.069	0.253	0.074	0.262
cottage	0.248	0.432	0.175	0.378	0.155	0.362
visit	0.681	0.466	0.593	0.492	0.418	0.494
income	13600	8471	11990	7056	11354	7702
female	0.540	0.499	0.551	0.498	0.500	0.500
WQA	81.92	15.11	73.47	19.50	65.71	27.27
age	42.29	13.61	42.36	15.23	46.19	15.82
U. County	0.105	0.307	0.137	0.343	0.167	0.374
N	1347		1248		533	

We will now proceed to a formal analysis where we mainly focus on response behavior in relation to the probability of program success.

4.1 Between sample

Before analyzing the data more thoroughly for the between-sample design, there are some structural differences associated with the between-sample design have to be addressed. The data were collected at the end of the summers of 1998 and 1999. In 1998, when data for the probabilities 0.5, 0.75 and 0.9 were collected, the temperature was below season average, rainfall above and there were low to moderate levels of algal blooms. In 1999, when data for the probabilities 0.1, 0.25 and 0.5 were collected, little rainfall, high temperatures and high levels of algal blooms characterized the summer.

Table 3 reveals that there are some structural differences in the data, especially with respect to income, visit and response behavior.

Table 3. Testing for structural differences, within-sample design excluded

variable	1998 mean (stdv.)	1999 mean (stdv.)	two-sided t-test of diff., p-values
visit	0.52	0.66	<0.001
income	11 619 (5 858)	12 945 (7 625)	<0.001
female	0.55	0.54	0.653
WQA	75.54 (19.76)	75.80 (20.77)	0.7889
age	43.05 (14.94)	43.85 (15.18)	0.264
U. County	0.13	0.13	0.770
WTP	65.434 (108.52)	73.837 (99.381)	0.056
response behavior			<0.001
% *definitely*	38.5	47.1	
% *probably*	44.8	40.7	
% *no*	16.7	12.2	
N	1413	663	

For the year 1998 (lower temperatures, more rainfall, higher probabilities of reversibility (0.5, 0.75 and 0.9) and low/moderate levels of algae blooms) there are on average more people who answer *no* and less people who answer *definitely* (this is very surprising considering that the probabilities of reversibility are higher, more on this later), average income is lower and there are fewer visits. Fortunately the data set is rich enough, enabling us to account for these structural differences by testing the two years apart. Although we cannot compare all subsamples, we can compare the responses for those who faced a success probability of 0.5 with those who faced a probability of 0.1 and 0.9, which still is a significant difference. Table 4 reports the results.

For the year 1998 we find that the dummy d75 is not significant. The dummy d90 is significant at the ten percent level. However, the coefficient does not have the expected sign. The variables visit, income, and WQA are all statistically significant and have expected positive signs, meaning that the probability to answer *definitely* increases with income and is higher for a person who made a visit to the archipelago during the summer and who has a high assessment of water quality. The variable U. County is also significant but has a positive sign, which is not what we expected. Age has a negative sign and is the most influential variable (looking at the marginal effects).

Table 4. Ordered probit estimates for 1998 and 1999

	1998			1999		
variable	coeff.	p-value	marg. eff.	coeff.	p-value	marg. eff.
constant	0.924	<0.001	<0.001	0.979	<0.001	<0.001
visit	0.001	0.011	<0.001	-0.000	0.459	-0.001
income	<0.001	<0.001	<0.001	<0.001	0.038	<0.001
female	0.035	0.563	0.014	-0.003	0.597	-0.001
WQA	0.001	<0.001	<0.001	<0.001	0.117	<0.001
age	-0.006	0.002	-0.003	-0.000	0.753	<0.001
U. County	0.003	0.042	<0.001	-0.124	0.352	-0.614
d10	-	-	-	0.066	0.552	0.022
d25	-	-	-	0.060	0.578	0.024
d75	-0.031	0.669	-0.012	-	-	-
d90	-0.314	0.060	-0.054	-	-	-
μ	1.310	<0.001		1.2526	<0.001	
N	1413			663		
$\chi^2\,(r)$	86.757	<0.001		11.363	0.182	
LRI	0.03			0.009		
Log L	-1406.535			-642.339		
response behavior						
% definitely	38.5			47.1		
% probably	44.8			40.7		
% no	16.7			12.2		

For the year 1999, the reversibility dummies are not significant, in this case d10 and d25. In fact for this year, only income is significant. Moreover, the chi-two test of the null hypothesis that all slopes are equal to zero cannot be rejected. This is not likely to be an effect of that more respondents answer *no* in 1999 however; on the contrary 12 percent answer *no* this year, while 17 percent did so in 1998.

To summarize, most significant variables (all but U. County and d90 for 1998) shows expected signs. However, based on the results obtained so far we have to reject the main hypothesis as our results indicate that the degree of reversibility makes no difference for response behavior. Is this really the case or are there any other circumstances causing this result?

It has been argued and demonstrated that failures to show sensitivity so scope can occur for psychological reasons, but still be compatible with economic fundaments (see Heberlein et al 2005). We will analyze two potential reasons.

It is important to realize that the respondents express behavioral intentions and that these could be biased in several ways. First, since respondents answers are expressed intentions rather than actual behavior there could be a hypothetical bias. In CVM studies a common concern is that the budget restriction is not taken into enough account by respondents, which would imply that the stated willingness to pay is in fact much higher than what consumers would actually pay. In this setting it could have the consequence that people are more prone to answer *definitely* when they in fact are not so certain and could thereby disregard relevant information such as probability of reversibility.

Table 5 Binary probit estimates for 1998 and 1999, (probably and no pooled)

	1998			1999		
variable	coeff.	p-value	marg. eff	coeff.	p-value	marg. eff
constant	-0.537	<0.001	-0.204	-0.177	0.128	-0.071
visit	0.001	0.006	0.340	-0.000	0.343	-0.000
income	<0.001	<0.001	<0.001	<0.001	0.103	<0.001
female	-0.001	0.994	-0.000	-0.003	0.602	-0.001
WQA	0.001	0.004	<0.001	<0.001	0.580	<0.001
age	-0.001	0.554	-0.001	-0.000	0.212	-0.000
U. County	<0.001	0.167	<0.001	-0.160	0.283	-0.063
d10	-	-	-	0.036	0.767	0.014
d25	-	-	-	-0.027	0.821	-0.011
d75	0.006	0.946	0.002	-	-	-
d90	-0.115	0.175	-0.043	-	-	-
N	1413			663		
χ^2 (r)	46.967	<0.001		8.130	0.421	
LRI	0.025			0.009		
Log L	-918.22			-454.344		
response behavior						
% *definitely*	0.385			0.471		
% *no/probably*	0.615			0.529		

One approach aiming at reducing hypothetical bias in CVM studies is to collect information about how certain respondents were about their answers to a willingness to pay question (see Champ et al., 1997; Champ and Bishop, 2001; Blumenschein et al., 2004). The fact that our respondents could answer *definitely*, *probably* or *no* enables us to carry out a similar adjustment of hypothetical bias by testing the consequences of pooling *probably* and *no* answers. This is based on the argument that only those who answer *definitely* would accept the scenario in a real-world situation.

This means that the proportion of answers interpreted as *no* (*no/probably*) increases from 17 percent to 62 percent for 1998, and from 12 percent to 53 percent for 1999. However, the estimation results in Table 5 show that reversibility remains insignificant. Visit, income and WQA remains significant and positive for 1998. U. County is now not significant however. For the year 1999 there are no significant variables.

Answers can also be affected by knowledge and experience with the good. Heberlein et al (2005) analyzed four contingent valuation studies with respect to scope using both traditional methods as well as methods from psychological theory. They found that responses are more likely to be valid when respondents have knowledge about and experience with the good. In this study the good (increased water quality) is complex and perhaps only people familiar with the good give valid answers in the sense that they take the degree of reversibility into account.

Table 6. Ordered probit estimates for 1998 and 1999, visitors

	1998			1999		
variable	coeff.	p-value	marginal eff.	coeff.	p-value	marginal eff.
constant	1.125	<0.001	<0.001	2.238	<0.001	<0.001
income	<0.001	<0.001	<0.001	<0.001	0.847	<0.001
female	-0.062	0.497	-0.025	-0.003	0.652	-0.001
WQA	0.001	0.020	<0.001	0.001	0.2883	<0.001
age	-0.003	0.358	-0.001	-0.017	<0.001	-0.007
U. County	<0.000	0.264	<0.001	0.137	0.595	0.054
d10	-	-	-	0.030	0.843	0.012
d25	-	-	-	0.025	0.867	0.009
d75	-0.027	0.801	-0.011	-	-	-
d90	-0.112	0.317	-0.045	-	-	-
μ	1.436	<0.001		1.511	<0.001	
N	655			389		
$\chi^2\,(r)$	22.876	0.002		22.751	0.002	
LRI	0.018			0.034		
Log L	-607.785			-328.145		
response behavior						
% definitely	0.456			0.534		
% probably	0.446			0.404		
% no	0.098			0.062		

We do not have a "knowledge parameter" but we have data on people who made at least one visit to the archipelago during the summer. Visitors are likely to have more experience of the problems of eutrophication than non-visitors, and might thereby be able to make a more informed judgment. Tables 6 and 7 show the estimations results for these two groups.[4]

[4] In these estimations residents were excluded from the estimations since we believe that those responses could be biased by strategic motives. However, we have also analyzed the case where residents were included but that did not affect response behavior.

Table 7. Ordered probit estimates for 1998 and 1999, non-visitors

	1998			1999		
variable	coeff.	p-value	marginal eff.	coeff.	p-value	marginal eff.
constant	0.746	<0.001	<0.001	0.129	0.559	<0.001
income	<0.001	<0.001	<0.001	<0.001	0.002	<0.001
female	0.192	0.032	0.069	0.240	0.129	0.088
age	-0.009	0.002	-0.003	0.002	0.079	0.001
WQA	0.001	0.007	<0.001	<0.001	0.831	<0.001
U. County	0.001	0.015	<0.001	0.100	0.561	0.037
d10	-	-	-	-0.121	0.951	-0.005
d25	-	-	-	0.106	0.558	0.039
d75	-0.022	0.835	-0.008	-	-	-
d90	-0.123	0.257	-0.044	-	-	-
μ	1.266	<0.001		1.219	<0.001	
N	650			222		
$\chi^2(r)$	44.780	<0.001		18.927	0.008	
LRI	0.032			0.040		
Log L	-667.843			-227.419		
response behavior						
% definitely	0.315			0.337		
% probably	0.452			0.432		
% no	0.232			0.229		

This exercise demonstrates that people with experience and knowledge of the good respond differently to those with less experience, however, the reversibility dummies remains insignificant for both groups.

Although this is not a CVM study, using willingness to pay as a dependent variable could provide richer results.

Table 8. OLS regression estimates (WTP dependent variable) for 1998

	All responses		visitors		non-visitors		*probably* and *no* pooled	
variables	coeff.	p-value	coeff.	p-value	coeff.	p-value	coeff.	p-value
constant	8.519	0.815	179.37	0.099	-18.20	0.757	48.23	0.410
visit	0.105	0.129	-	-	-	-	0.128	0.250
income	0.002	0.242	0.001	0.771	<0.001	0.935	0.002	0.540
female	-24.98	0.187	-104.84	0.058	16.16	0.613	-48.93	0.108
WQA	0.068	0.436	-1.918	<0.001	0.044	0.700	-0.497	<0.001
age	-1.309	0.040	-1.257	0.516	-0.791	0.443	-0.966	0.347
U. County	0.047	0.269	0.067	0.554	0.033	0.665	0.072	0.287
d75	-9.071	0.691	21.576	0.746	37.93	0.324	20.31	0.580
d90	-32.176	0.165	61.057	0.371	-52.01	0.178	-2.303	0.951
N	1410		655		650		1413	
F-test	1.74	0.085	6.03	<0.001	0.96	0.458	2.54	0.010
Adj.R-square	0.004		0.051		<0.001		0.009	

Table 8 shows that for the year 1998, the reversibility dummies are insignificant. Moreover, separating the respondents into groups or correcting for a potential hypothetical bias make no difference for response behavior with respect to reversibility.

Table 9. OLS regression estimates (WTP dependent variable) for 1999

	All responses		Visitors		Non-visitors		*Probably* and *no* pooled	
variables	coeff.	p-value	coeff.	p-value	coeff.	p-value	coeff.	p-value
constant	-61.60	0.055	-54.06	0.285	-604.23	<0.001	-61.60	0.055
visit	0.167	0.176	-	-	-	-	0.167	0.176
income	0.003	0.043	0.002	0.362	0.013	0.007	0.003	0.043
female	-0.053	0.878	-0.071	0.862	40.88	0.561	-0.053	0.878
WQA	0.161	0.088	0.093	0.626	0.430	0.013	0.161	0.088
age	-0.074	0.560	-0.091	0.641	0.381	0.180	-0.074	0.560
U. County	51.29	0.206	68.22	0.438	155.27	0.043	51.29	0.206
d10	-38.86	0.244	-77.46	0.135	97.26	0.260	-38.86	0.244
d25	-65.83	0.044	-125.78	0.013	133.52	0.096	-65.83	0.044
N	663		389		222		663	
F-test	1.81	0.073	1.20	0.302	3.75	<0.001	1.81	0.073
Adj.R-square	0.009		0.004		0.080		0.010	

However, for the year 1999, the dummy d25 is significant and has the expected sign. Moreover, when we separate the respondents into visitors and non-visitors we see that d25 is only significant for visitors, which supports the hypothesis that knowledge of the good and experience with the good are likely to produce more valid responses. We also corrected for hypothetical bias but that did not improve results.

Instead of a probability effect, for the between sample design we consistently find a strong year effect. In 1999, although the probabilities are in the lower range, the share of the respondents who answer *definitely*y is significantly higher and the share who answer *no* is significantly lower (see Table 3) than in 1998. To refresh your memory, 1999 was the year with higher temperatures, less rainfall and higher levels of algae blooms. For this year we also found few significant explanatory variables. For the year 1998 on the other hand, people are more cautious and take more factors into consideration when making their responses. Too see if the year effect can be explained solely by the percentages or/and if the explanation is to be found in other variables (such as weather and levels algae blooms) we run an ordered probit for the subsample where the success probability is 50 per cent and then include a dummy for 1999 (d1999), see Table 10 below.

Table 10. Ordered probit estimates for subsample 50

variable	coeff.	p-value	marg. eff.
constant	0.731	<0.001	<0.001
income	<0.001	<0.001	<0.001
female	-0.003	0.617	-0.001
age	-0.000	0.605	-0.000
WQA	0.001	0.004	<0.001
U.County	<0.001	0.230	<0.001
d1999	0.071	0.451	0.028
μ	1.293	<0.001	
N	692		
$\chi^2(r)$	36.08	<0.001	
LRI	0.026		
Log L	-679.18		
response behavior			
% definitely	0.434		
% probably	0.413		
% no	0.147		

Table 10 reveals that the year dummy is not significant (or even close to being significant). The year effect thus seems to be due solely to the probabilities.

To further evaluate this reverse probability effect we analyze each subsample separately which means we control for the year effect. Table 11 shows that there is indeed an internal reverse effect for 1998 as well as for 1999. For 1998 the share of people who answer *definitely* decreases as the probability of program success increases (and vice versa for those who answered *no*). For 1999 this effect is not present.

Table 11. Response behavior for each subsample and year

subsample	response behavior	1998	1999
10	*% definitely*		0.485
	% probably		0.392
	% no		0.121
25	*% definitely*		0.458
	% probably		0.445
	% no		0.096
50	*% definitely*	0.400	0.468
	% probably	0.445	0.381
	% no	0.144	0.150
75	*% definitely*	0.395	
	% probably	0.434	
	% no	0.170	
90	*% definitely*	0.358	
	% probably	0.454	
	% no	0.186	

4.2 Within sample

From the results obtained so far one could be tempted to conclude that the degree of reversibility does not have an expected effect on peoples response behavior. However, this result seems to depend crucially on the between-sample design. A completely different picture appears when the data for the within-sample design are analyzed; see Table 12 for estimation results.[5]

[5] For the within-sample design no adjustment for structural differences was necessary because all data for the within-sample design were collected in 1999.

Table 12. Random effects ordered probit estimates

variable	coeff.	p-value	marg. eff.
constant	-1.713	0.044	<0.001
visit	0.343	0.326	0.052
income	<0.001	0.320	<0.001
female	-0.023	0.947	-0.003
age	0.004	0.739	<0.001
U. County	0.543	0.318	0.083
d10	-2.383	<0.001	-0.334
d25	-1.291	<0.001	-0.191
d75	1.253	<0.001	0.188
d90	1.714	<0.001	0.273
μ	2.849	<0.001	
σ	2.421	<0.001	
N	1055		
$\chi^2\,(r)$	711.925	<0.001	
LRI	0.371		
Log L	-604.232		
response behavior			
% definitely	55.0		
% probably	38.8		
% no	6.2		

Reversibility is now strongly significant, both statistically and economically. The dummy variables for the different probabilities of success also have the "right" signs, meaning that the probability of to answer *definitely* increases for percentage rates above 50 percent and decreases for percentage rates below 50 percent. No other variable is significant though; the reversibility dummies clearly dominate all other variables.

Not surprisingly, analyzing the response behavior for each probability separately shows that the share of respondents who answer *definitely* consistently increases when the probability of success increases (and vice versa for the share who answer no).

Table 13. Response behavior for each probability (9010),

	10	25	50	75	90
definitely	0.213	0.274	0.445	0.654	0.744
probably	0.298	0.440	0.417	0.279	0.208
no	0.488	0.284	0.137	0.066	0.047

4.3 Puzzles and answers

In the ordered probit estimates, people do not respond to the probabilities of success in the between sample design (we only found one significant dummy but with opposite sign). Our attempt to reduce the hypothetical bias did not help us understand this behavior and although we found that visitors and non-visitors respond differently, they did not do so with respect to the uncertainty. We were also puzzled by the strong year effect observed in the between sample design. More people are willing to accept to pay something although the probabilities of success are lower for this year. We found that this effect had more to do with the probabilities than year. Although it is not completely picked up in the ordered probit estimates (there is one exception, d90 for 1998), we found evidence of a reverse probability effect. However, when each respondent faced all probabilities not only did we find that the probabilities dominated all other decision variables, but also that they had the expected sign. It is not surprising that people respond differently depending on design, but we find the magnitude of this difference quite striking. Perhaps most respondents view the water quality issue as so important that it consistently tends to overrule the uncertainty factor unless it is not explicitly made clear to them (as in the within-sample design) that several different probabilities might be possible. In fact, among the very few respondents who commented on the low probabilities in the 1999 sample there were opinions such as: "one should always give it (the abatement program) a try" (respondent #333) and "The odds are bad... but something has to be done, hasn't it? (respondent #1005).

5 Discussion and concluding remarks

The aim of this paper was to analyze how people respond to a potential irreversibility of environmental degradation in a typical CVM setting. We want again to emphasize though that this is not a CVM study and we have not been interested in estimating total willingness to pay. Instead our study was motivated by the empirical observation that many ecosystems have been degraded to the point where it is uncertain whether a healthy state can be recovered regardless of the amount of resources devoted to the purpose. Based on the extensive amount of empirical evidence we believe these kinds of situations to be increasingly frequent in the future and hence these kinds of questions to be increasingly important for future survey work.

Our results are mixed and depend crucially on valuation design. When each respondent faces one probability of reversibility, we find that the degree of uncertainty does not have the expected influence on responses. We even find a tendency for a reverse probability effect. This result is robust when we account for hypothetical bias and experience with the good. The within-sample design on the other hand shows that when a respondent faces different probabilities of reversibility, not only is this uncertainty characteristic significant and has the expected sign, but also dominates all other decision variables.

How do we explain the observed behavior? Insensitivity to scope is often attributed to warm glow motives (Andreoni, 1989, 1990). Such motives exist when a person contributes to a public good because the act of contributing in itself provides some benefit to the individual. This cannot be the story in our case because the within sample design shows that this is not the case. Moreover, if that were the case we would not find the strong year effect for the between sample.

It has been showed that people have a poor understanding of numerical differences in magnitude and that there are circumstances where people have problems of interpreting information, here about uncertainty, if no reference point is given (Kahneman et. al 1999). Our results show a similar tendency. These kinds of results have for example been found in CVM studies regarding reductions in health risks; stated willingness to pay is inadequately sensitive to both levels and changes in probabilities (see for example Hammitt and Graham (1999) and references therein). Could this be the explanation behind our results? These types of results are typical for complex probabilities, meaning that the base level of risk is very small as are the changes in risk. Neither of our probability levels nor the changes in them is very complex. However the good, increased water quality, as well as the problem description may still be complex enough to cause an insensitivity to the magnitude of uncertainty in a between-sample design.

So where do we go from here? For future survey work approaching similar issues, we recommend the use of detailed follow-up questions to give respondents opportunities to explain their responses. Without such additional information, valuation responses might be so difficult to interpret that conclusions giving policy recommendations are impossible to arrive at. This suggests that the design of such follow-up questions is a crucial area for future research. Such research should also consider that the optimal framing of follow-up questions might vary among survey methods. The fact that budget limitations in practice often preclude the use of face-to-face interviews suggests that there is a great need for suitable follow-up questions also in mail questionnaire settings.

6 Appendix - Scenarios

The original scenarios were in Swedish. This Appendix reprints a translation of the scenarios used in the two designs.

Between-sample design

The water in the Stockholm Archipelago might be improved if measures are taken against nutrient emission from e.g., agriculture and household sewage. Suppose that an abatement program has been proposed. According to this program, farmers and sewage treatment plants in the counties of Stockholm, Södermanland and Uppsala have to put money into measures against the nutrient emissions. This would in turn result in increased prices of agricultural products and tap water in these counties. The following would also happen:

- Nature is not completely predictable, so there is no guarantee that the proposed abatement program will succeed. Suppose the chance of successful measures would be very high (90 percent)/rather high (75 percent)/fifty-fifty (50 percent)/rather low (25 percent)/very low (10 percent).[6] If the program is successful

[6] The five sub-samples used in the between-sample design only differed with respect to what of the five descriptions of the chance of success was used.

the measures would improve the water quality in the archipelago.

- For example, the water transparency in the inner and central parts of the archipelago would on average increase from the present average of about 1 meter in the summers to about 2 meters in 10 years. As a rule, it would thus in 10 years be possible to discern one's feet on the bottom wherever one bathes in the archipelago. If the program is not successful, the water quality would not be improved, but the ongoing deterioration would continue at a slower rate than before.
- If no measures are taken, the ongoing deterioration would continue at the same rate as today, and the water would gradually become more turbid.

QUESTION. Would you accept or not accept to pay something in terms of increased expenses in order to make it possible to carry out this abatement program?

☐ I WOULD DEFINITELY ACCEPT
☐ I WOULD PROBABLY ACCEPT
☐ I WOULD NOT ACCEPT

QUESTION. What is the maximum increase in expenses that you would accept for this purpose? Please remember that your income has to suffice for other expenses too!

ANSWER. Not more than SEK ____________per month during 10 years.

Within-sample design

The water in the Stockholm Archipelago might be improved if measures are taken against nutrient emission from e.g., agriculture and household sewage. Suppose that an abatement program has been proposed. According to this program, farmers and sewage treatment plants in the counties of Stockholm, Södermanland and Uppsala have to put money into measures against the nutrient emissions. This would in turn result in increased prices of agricultural products and tap water in these counties. The following would also happen:

- Nature is not completely predictable, so there is no guarantee that the proposed abatement program will succeed. **If the program is successful,** the measures would improve the water quality in the archipelago.
- For example, the water transparency in the inner and central parts of the archipelago would on average increase from the present average of about 1 meter in the summers to about 2 meters in 10 years. As a rule, it would thus in 10 years be possible to discern one's feet on the bottom wherever one bathes in the archipelago. If the program is not successful, the water quality would not be improved, but the ongoing deterioration would continue at a slower rate than before.
- If no measures are taken, the ongoing deterioration would continue at the same rate as today, and the water would gradually become more turbid.

QUESTION. Would you accept or not accept to pay something in terms of increased expenses in order to make it possible to carry out this abatement program, if ...

a) ...the chance of successful measures would be very high (90 percent)?

☐ I WOULD DEFINITELY ACCEPT
☐ I WOULD PROBABLY ACCEPT
☐ I WOULD NOT ACCEPT

b) ...the chance of successful measures would be rather high (75 percent)?

☐ I WOULD DEFINITELY ACCEPT
☐ I WOULD PROBABLY ACCEPT
☐ I WOULD NOT ACCEPT

c) ...the chance of successful measures would be fifty-fifty (50 percent)?

☐ I WOULD DEFINITELY ACCEPT
☐ I WOULD PROBABLY ACCEPT
☐ I WOULD NOT ACCEPT

d) ...the chance of successful measures would be rather low (25 percent)?

☐ I WOULD DEFINITELY ACCEPT
☐ I WOULD PROBABLY ACCEPT
☐ I WOULD NOT ACCEPT

e) ...the chance of successful measures would be low (10 percent)?

☐ I WOULD DEFINITELY ACCEPT
☐ I WOULD PROBABLY ACCEPT
☐ I WOULD NOT ACCEPT

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