Decision making under inherent uncertainty: does preference analysis play a role in the design of wetland adaptation to climate change?

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The economic valuation of environmental policies' social benefits has traditionally relied on the simplifying assumption that policy's outcomes are certain rather than uncertain. However, the complexities inherent in ecosystems' dynamics make the magnitude and timing of the environmental outcomes difficult to predict. The presence of knowledge uncertainty, which is controllable and predictable, but especially of inherent uncertainty, which is uncontrollable and unpredictable, can lead to consider as optimal policies being less effective in terms of outcomes, intensity or implementation timing. In this context, and with a focus on wetland adaptation to climate change, this study analyzes the potential effects of inherent uncertainty on the policy's social desirability, where uncertainty is presented through different scenarios of probability of occurrence of climate change-derived impacts on wetlands' dependent species. Although this type of uncertainty cannot be controlled for, results give evidence that preference analysis can inform decision-making when it comes to inherent uncertainty settings, especially when policy design revolves around adaptation to uncontrollable, environmental circumstances.

Keywords: environmental policy, preference analysis, welfare analysis, inherent uncertainty, choice experiment, adaptation, climate change.

JEL codes: D6, D81, Q51, Q54.

1. Introduction

Cost-benefit analysis (CBA) of public policies cannot be undertaken under the assumption of certainty, as policy benefits and costs concern the present as well as the future and the future is uncertain. Thus, as an ex-ante assessment procedure, CBA forces the researcher to work on expectations. In this context, assuming certainty is a simplifying device. While it is convenient to assume away some real-world complexities to develop analytical insights, such simplifications should only be acceptable when the thing being ignored does not have major consequences for the analysis. Indeed, assuming certain the expectations about benefits and costs could seriously affect the policy's social return if events are not as expected, this leading to poorly-informed decision makers.

This is especially of concern when it comes to assessing environmental policies, as complexities inherent in ecosystems' dynamics make the magnitude and timing of policy outcomes even more difficult to predict. Non-linearities, irreversibilities and longer time horizons characterizing ecosystems' behavior add uncertainty to the achievement of environmental targets and, consequently, to the policy's social benefits. Overlooking uncertainty in environmental policy effectiveness can lead to consider as optimal policies being less effective in terms of outcomes, intensity or implementation timing (Pyndick, 2007). Therefore, the researcher should examine what difference it makes to the analysis of the policy's social benefits when uncertainty rather than certainty is assumed. In other words, analyzing the implications of considering uncertainty should be of interest in the valuation of social benefits due to the potential effects of uncertainty on the policy's social profitability.

Despite this, dealing with uncertainty has been a recent phenomenon in the environmental valuation literature likely due to technical and operational challenges (Wang and Rolfe, 2009; Akter and Bennett, 2012). Besides, the focus has been mostly on knowledge uncertainty, defined either as a lack of information on which to draw inferences or as an incomplete understanding of events and processes leading to an environmental outcome. As this type of uncertainty depends on the availability of information, it can be reduced by policy makers by gaining knowledge through education, training or expert advice (Langsdale, 2008). In this context, most of studies have explored social preferences *for* and *under* knowledge uncertainty in an attempt to better inform policy makers. First, researchers have been interested in knowing the social value *for* uncertainty reduction to be able to compare it with the costs required to undertake an uncertainty-reducing policy. Second, information about the social welfare gain linked to given environmental outcomes achieved *under* different uncertainty scenarios has captured the attention of researchers pursuing to give guidance on how to improve policy performance, and hence effectiveness. Indeed, both approaches have been motivated by the fact that planners often consider scientific certainty as a prerequisite for decision-taking in environmental policy (Mitchell, 2002; Sethi et al., 2005).

However, knowledge-based uncertainty is not the only source of uncertainty faced by policy makers. The ordinary variability of natural systems due to interactions among physical, chemical, ecological and human factors leads to the existence of inherent uncertainty (Thom et al., 2004). That is, the randomness of natural processes can make that an environmental policy, even if it is perfectly executed, can still fail to meet a performance target. Despite increasing claims for considering this type of uncertainty in environmental policy design, it has been traditionally overlooked (Young, 2001; Heal and Kriström, 2002; Berkes, 2007; Ascough II et al., 2008; Weitzman, 2013; Heal and Millner, 2014) as, after all, decision makers cannot control for it. Consequently, little attention has been paid to this type of uncertainty in the valuation literature.

Nevertheless, although inherent uncertainty cannot be reduced, preference analysis is also expected to play a role when it comes to giving guidance to policy makers. Indeed, while environmental policy results cannot be guaranteed by any means, knowledge about the social value assigned to a series of possible policy outcomes achieved *under* potential, different uncertainty scenarios can improve adaptation to unavoidable, unpredictable environmental contexts. Efficient adaptation relies on an understanding of the motives, behaviour and values of the many actors being affected by the environmental circumstances that are uncertain in timing and magnitude (Belle and Bramwell, 2005). It is worth noting that environmental policy results not only depend on the evolution of ecosystem dynamics and its characterizing complexities. They also depend on the capability of policy makers for adaptation *under* uncontrollable, environmental circumstances. Thus, actions leading to building a greater adaptive capacity will give to them more control over the inherent uncertainty impacts on policy effectiveness. Gaining knowledge on the social benefits of environmental policies *under* inherent uncertainty scenarios is one of these actions.

Examining the relevance of preference analysis for decision-making in a context of inherent uncertainty is the purpose of this paper. To do this, the article investigates the implications for welfare estimates of different uncertainty scenarios with a focus on climate change (CC)-derived impacts on wetlands' biodiversity. On the one side, CC is an environmental problem characterized by many inherent uncertainties. It is difficult to predict the alteration in the climate system because of the unforeseen variations and trends both in the drivers of change (greenhouse gases, aerosols, clouds microphysics, etc.) and in the associated responses of the system (especially change in precipitations, extreme weather events, etc.) (IPCC, 2013). On the other one, wetlands are ecosystems that are very rich in biodiversity and highly sensitive to climate, thus becoming one of the most threatened ecosystems by CC (Russi et al., 2013). More specifically, the paper estimates, through a choice experiment (CE) applied to S'Albufera wetland (Mallorca), the social benefits associated with adaptation policies under alternative, uncertain scenarios defined by different probabilities of occurrence of CC-derived impacts on wetlands.

The structure of the paper is as follows. Next section reviews how the environmental valuation literature has treated uncertainty issues to show that research concerned about inherent uncertainty is scarce. Section 3 describes the methodology used to analyse the relevance of preference analysis for decision-making when it comes to inherent uncertainty. Results are reported in section 4, followed by a discussion and conclusions section that ends the paper.

2. Treatment of uncertainty in the environmental valuation literature

Non-linearities, irreversibilities and longer time horizons characterizing ecosystems' behavior make uncertain the achievement of environmental policies' targets. As this can have an impact on policies' social profitability, over recent years uncertainty issues have captured the attention of environmental economists working on stated preference (SP) methods. Indeed, uncertainty-related considerations force the analyst to work on expectations, this leading to ex-ante economic valuations that can only be carried out through the use of hypothetical behavior-based techniques. Among these ones, the contingent valuation (CV) method and the choice experiment (CE) have been the most widely used. In this sense, and despite the existence of previous CV works dealing with mortality and health risks, SP literature recognizes Johansson (1989) as the starting point study (Akter and Bennett, 2012).

Given the recognition that uncertainty is an obstacle for decision-making and therefore should be ideally eliminated, researchers have mainly focused on the analysis of social preferences *for* knowledge uncertainty. This type of uncertainty is reducible by gathering additional information through education, training or expert advice (Langsdale, 2008). In this sense, SP literature has been mostly focused on estimating the social benefits *for* uncertainty reduction to be able to compare them with the costs required to undertake an uncertainty-reducing policy.

Within this framework, while CV studies have incorporated uncertainty into the hypothetical market description (Fried et al., 1999; Fu et al., 1999; Krupnick et al., 1999; Bateman et al., 2005; Alberini et al. 2006; Wang and Mullahy, 2006; Hammitt and Zhou, 2006; Alberini and Chiabai, 2007), most CE applications have dealt with the limited understanding of the natural events and processes leading to an environmental outcome by using an attribute expressing its associated probability or risk. Examples are studies considering one attribute to represent the probability of algal bloom episodes (Roberts et al., 2008), flood occurrence (Zhai, 2006; Birol et al., 2009; Dekker and Brouwer, 2010; Brouwer and Schaafsma, 2013; Reynaud and Nguyen, 2013), and provision of additional water supply (Rigby et al., 2010), as well as studies using one attribute describing the risk of species' extinction (Mitani et al. 2008; Bartczak and Meyerhoff, 2013) and pollution (Cerroni et al., 2013). The level of scientific knowledge about environmental processes has also been used as an uncertainty informing attribute in this type of CEs (Koundouri et al., 2013). Additionally, some other, less abundant CE studies have dealt with the incomplete understanding of the technical performance of an environmental intervention through the use of a single attribute, reflecting the degree of policy effectiveness. Examples of this are studies presenting the probability of either achieving a given emission reduction target (Ivanova et al., 2010; Glenk and Colombo, 2011) or a specific conservation goal (Lundhede et al., 2012; Rolfe and Windle, 2014). Regardless of the source of knowledge uncertainty, these studies show a positive willingness to pay (WTP) *for* an uncertainty reduction. Then, they seem to suggest that the implementation of uncertainty-reducing policies is socially desirable.

The analysis of social preferences *for* an uncertainty reduction has not been the only interest of researchers concerned about knowledge uncertainty. Indeed, some environmental economists have focused on giving planners some guidance on how to optimally improve policy performance and hence effectiveness *under* uncertainty. Indeed, some studies have investigated the WTP for given environmental improvements *under* different uncertainty scenarios. In particular, they have incorporated uncertainty into the scenarios' descriptions as the basis to conduct an analysis of either WTP sensitiveness (Isik, 2006; Wielgus et al., 2009; Lew et al., 2010) or individuals' attitudes toward risk (Macmillan et al., 1996). According to expectations, results indicate that the WTP for a given environmental improvement tends to be smaller in the presence of uncertainty rather than certainty. Again, these analyses seem to suggest a positive social desirability *for* uncertainty-reducing policies showing, in many cases, that WTP is sensitive to the type of uncertainty scenario (Isik, 2006; Wielgus et al., 2009; Lew et al., 2010).

A literature review shows that research has not only been focused on knowledge uncertainty issues. Indeed, few studies have centered on a different type of uncertainty derived from the ordinary variability of natural systems. Interactions among physical, chemical, ecological and human factors characterizing ecosystems lead to the existence of inherent uncertainty which is also faced by policy makers. However, the impossibility of being controlled by them due to its random character would help explain the little attention paid to this type of uncertainty in the valuation literature. To our knowledge, the only research attempts in this field are Johansson (1989), Cameron (2005) and Viscusi and Zeckhauser (2006). The former examines the risk attitudes of individuals in the face of uncertainty about future states of the world, finding risk-aversion, as in Macmillan et al. (1996). The latter two analyze the sensitiveness of the WTP for different mitigation policies to subjective probabilities of occurrence of CC.

In the light of this, it can be observed that, despite the increasing interest in dealing with uncertainty issues in the valuation literature, the number of studies is still low. This is especially true when it comes to inherent uncertainty. SP literature has traditionally overlooked it, thus implicitly assuming this type of uncertainty has no impacts on welfare estimates and, consequently, on policy's social profitability. However, this is a strong assumption. The fact that policy effectiveness can be affected by the existence of inherent uncertainty obliges to be cautious and, at least, to analyze its potential implications for the measurement of policy benefits. In an attempt to shed some light on this issue, this paper examines the relevance of preference analysis for decision making when uncertainty remains inherent, thus contributing to this emerging literature. More specifically, with a focus on CC-derived impacts on wetland-dependent species, it wants to provide guidance on the importance of considering inherent uncertainty in welfare estimation when adaptation policy design is the focus.

3. Methodology

As shown in the previous section, welfare estimation under uncertain scenarios has been undertaken through SP methods as individuals face environmental quality settings they have not experienced in the past. In this context, the advantages of CEs over the CV method make much more appropriate the use of the former to shed some light on the issues dealt with in this paper. Indeed, CEs allow estimating not only the values for the attributes of a range of goods, services and policy designs, but also the compensating or equivalent surplus for a series of outcomes specified in terms of changes in multiple attribute levels. In this sense, they give the possibility to value possible outcomes in case of uncertainty of attribute levels, whereas the CV method only permits to obtain one value for one expected quality change (Garrod and Willis, 1999; Hanley et al., 1998; Hanley et al., 2001; Torres et al., 2011). The use of CEs to analyze uncertainty issues gives much more information, and hence can better inform policy makers. This is why this paper uses a CE study to examine the relevance of preference analysis for decision-making when it comes to inherent uncertainty.

3.1. The choice experiment design

The CE application to S'Albufera wetland (Mallorca) described in Faccioli et al. (2014) has been used as a reference study (REF_CE) for the analysis. Firstly, S'Albufera wetland is outstandingly vulnerable to the risks associated with both the increase in temperatures and the decrease in precipitation rates expected for the Mediterranean region as a consequence of CC. Secondly, REF_CE focuses on the analysis of visitors' preferences for adaptation policies aimed at counteracting the expected CC-derived impacts on bird species. In particular, it centers on the effects on both 'specialist' bird species, which mostly rely on S'Albufera habitat, and 'generalist' migratory bird species, which suit a wider habitat range and move to this humid land for resting and breeding. Therefore, it puts the emphasis on the analysis of the social benefits linked to two types of wetlands' adaptation policies: a) those aimed at preserving species' diversity and, hence, the original heterogeneity of the wetland, by avoiding a quantitative loss of 'specialist' species; b) those oriented to recovering species' abundance, by avoiding a quantitative loss of species, regardless of the species' type. Thirdly, following the main approach in the valuation literature, REF_CE assumes that both CC-derived impacts occur with certainty, that is, with a probability equal to 100%, within a given time horizon which is set to 10 years in the future.

According to this, it becomes a useful case study to test for the implications of inherent uncertainty for the social benefits of adaptation policies in a CC context. As probabilities have been widely used in the literature to communicate uncertainty (Lipkus, 2007; Wielgus et al., 2009; Spiegelhalter et al., 2011) two probability values different from 100% have been considered to define two uncertain scenarios within the same time horizon, in order to compare the derived welfare estimates with those from REF_CE. More precisely, two different CEs, namely CE_80 and CE_60, have been undertaken assuming a probability of CC impacts' occurrence of 80% and 60%, respectively. These values have been chosen following the IPCC guidelines, which define the events as 'virtually certain', 'likely' and 'about as likely as not' when they have a probability of occurrence ranging from 99% to 100%, 66% to 99%, and 33% to 66%, respectively (Mastrandrea et al. 2010).

Table 1 reports the attributes employed in REF_CE, and consequently in CE_80 and CE_60, to generate the experimental design, which is a D-efficient Bayesian:[1]

Table 1. Attributes' description and their levels

Attribute	Description	Levels
'Specialist' bird species	Change in the number of species[a]	+5, 0, -10[c]
'Generalist' migratory bird species	Change in the number of species[a]	+5, 0, -10[c]
Waiting time	Minutes waited for an observation cabin's seat	About 3, About 7, About 15[c]
Rest-stop benches	Number of benches throughout the park[b]	Triple, Double, Equal[c]
Entrance fee	Entrance fee per adult visitor and trip (in euros)	4, 8, 12, 16, 20, 24

[a] Changes with respect to the current number of 'specialist' and 'generalist' migratory bird species.
[b] Number measured with respect to the current level of rest-stop benches.
[c] BAU levels, being €0 for the Entrance fee attribute.

For simplicity reasons, only the effect of inherent uncertainty on the number of 'specialist' bird species has been considered for the analysis.[2] Thus, REF_CE, CE_80 and CE_60 differ from each other in the probability values assigned to the three levels of the 'specialist' bird species attribute reported in Table 1. However, as these probabilities refer to the occurrence of CC-derived impacts, three additional attribute levels have also been considered for the cases in which these impacts do not take place within the 10 years' time horizon. That is, in each CE, respondents have also been informed about the attribute levels resulting from the scenarios characterized by the absence of CC-derived impacts, which have been assigned a probability of 20% in CE_80 and 40% in CE_60. Therefore, REF_CE, CE_80 and CE_60 differ from each other in the probability values assigned to the assumed changes in the number of 'specialist' bird species. In other words, they differ from each other in the expected values considered for the attribute levels. The levels of the remaining attributes have been kept constant among the three CEs. Table 2 shows the levels considered for this *uncertain* environmental attribute under the occurrence (YES) and non-occurrence (NO) of CC-derived impacts for each CE:

Table 2. Levels of 'specialist' bird species attribute under the scenarios of CC-derived impacts' occurrence and non-occurrence in REF_CE, CE_80 and CE_60[a]

	REF_CE		CE_80		CE_60	
	CC-derived impacts		CC-derived impacts		CC-derived impacts	
	YES	NO	YES	NO	YES	NO
Attribute levels	**100%**	**0%**	**80%**	**20%**	**60%**	**40%**
Level 1	+5	+10	+5	+10	+5	+10
Expected level 1	*5*		*6*		*7*	
Level 2	0	+5	0	+5	0	+5
Expected level 2	*0*		*1*		*2*	
Level 3	-10	0	-10	0	-10	0
Expected level 3	*-10*		*-8*		*-6*	

[a]The expected levels result from the sum of the two attribute levels weighted by their probability of occurrence in each CE.

Two sample choice cards, one for REF_CE and another one for CE_60, are shown in Figures 1a and 1b:

[INSERT FIGURES 1a AND 1b]

[1] See Faccioli et al. (2014) for a detailed description of the experimental design.
[2] Findings from a pilot survey prior to the final one showed that the assumption of certainty of CC-derived impacts on 'generalist' migratory bird species was perceived as credible by visitors.

To conduct the analysis of the present study, two additional samples of respondents were randomly drawn from the population of visitors to S'Albufera wetland during the period in which the REF_CE was undertaken. As for REF_CE, data for CE_80 and CE_60 were collected by means of on-site interviews. Table 3 summarizes the relevant information about both sampling procedures and compares it with that of REF_CE:

Table 3. Information about data collection for REF_CE, CE_80 and CE_60

	REF_CE	CE_80	CE_60
Sample size	322	321	310
Confidence interval	95%	95%	95%
Sample error	5.47%	5.50%	5.57%

3.1.1 Risk attitude analysis

To enrich the analysis about the sensitivity of welfare estimates to different inherent uncertainty scenarios, visitors' attitudes toward risk have been also analyzed. To do this, another CE (CE_50) has been undertaken on the basis of the experimental design followed in REF_CE. An additional sample of respondents consisting of 318 individuals was randomly drawn from the population of visitors to S'Albufera. For this CE, a value of 50% has been assumed for the probability of CC-derived impacts' occurrence, meaning the maximum level of uncertainty. However, CE_50 differs from REF_CE in terms not only of the probability value but also of the three attribute levels, which have to be set in such a way that the derived expected values are equal to those in REF_CE. Indeed, the degree of risk aversion of individuals can only be examined by comparing their preferences under two scenarios showing equal expected outcomes, where one is certain with a probability of 100% and the other one is uncertain with a positive probability different from 100%.

Table 4 reports the levels of the 'specialist' bird species attribute for the REF_CE and CE_50 under both CC-derived impacts' occurrence and non-occurrence:

Table 4. Probabilities and levels of the 'specialist' bird species attribute in REF_CE and CE_50[a]

	REF_CE		CE_50	
	CC-derived impacts		CC–derived impacts	
	YES	NO	YES	NO
Attribute levels	**100%**	**0%**	**50%**	**50%**
Level 1	+5	+10	+4	+6
Expected value 1	*5*		*5*	
Level 2	0	+5	-4	+4
Expected value 2	*0*		*0*	
Level 3	-10	0	-16	-4
Expected value 3	*-10*		*-10*	

[a]The expected levels result from the sum of the two attribute levels weighted by their probability of occurrence in each CE.

3.2. Modelling choices in the face of risk

Preference analysis through CEs is carried out on the basis of the random utility maximization (RUM) theory. In this sense, individual choices are modelled by assuming respondent *n* chooses the alternative *j* providing him with the highest utility level from among a set of options. As shown in Equation 1, utility is defined as the sum of two components. First, a deterministic part $V_{nj}(\cdot)$ consisting of the alternative's non-monetary (X_{nj}) and monetary ($X_{COST_{nj}}$)

attributes, as well as a set of parameters (β) to be estimated. Second, a stochastic part ε_{nj} capturing all the unobserved factors affecting choice and indicating the analyst's incomplete knowledge about the individual decision process:

$$U_{nj} = V_{nj}(X_{nj}, X_{COST_{nj}}, \beta) + \varepsilon_{nj} \quad (1)$$

Consideration of risk in RUM-based individual choice modelling has led researchers to develop a specific analytical framework known as expected utility (EU) theory, which was initially formalized by von Neumann and Morgenstern (1944). According to EU theory, decision-making in the face of risk is driven by the maximization of the EU, which is defined as the sum of the utility levels individuals get from a series of possible K outcomes weighted by their probability of occurrence π_k:

$$\text{EU} = \sum_{k=1}^{K} \pi_k \, U(y_k) \quad (2)$$

where y_k is the outcome k out of the set of K possible outcomes.

EU theory assumes that people display preferences over y_k, and not over π_k itself and it incorporates considerations of people's attitude towards risk, affecting the shape of $U(y_k)$. Despite this paper focuses on uncertainty rather than risk, the fact that probabilities have been used to define the alternative uncertain scenarios makes the EU framework appropriate for the analysis. In fact, working on probabilities does not preclude the analyst from dealing with uncertainty issues provided the assumed probabilities are arbitrary. Put another way, randomly choosing probability values from the whole range of probabilities (0% to 100%) is equivalent to recognizing the impossibility of assigning probabilities to each possible outcome –that is, it is equivalent to assume uncertainty.[3]

As in Faccioli et al. (2014), parameter estimation has been carried out through a random parameter logit (RPL) model. Its many advantages over the conditional logit model have led to an increasing use of the former over the last decade (McFadden and Train 2000; Train 2009). The major one consists in taking individual-specific preferences into account, by assuming parameters are random and follow a given distribution. This is because the RPL model assumes that the sources of heterogeneity affecting the random attribute parameters are unknown, this leading to the use of a random density function to describe heterogeneity in these coefficients. In other words, the coefficients result from the sum of a population mean parameter and an individual-specific deviation over this mean. In the present analysis, and following the common approach in the literature, only the cost parameter has been considered to be random (Meijer and Rouwendal, 2006; Rischatsch, 2009; Beharry-Borg and Scarpa, 2010; Sagebiel, 2011). Besides, it has been assigned a lognormal distribution to constrain the coefficient to have the same sign over all individuals (Torres et al., 2011).

Equation 3 shows the utility function specification used for estimation purposes in REF_CE, CE_80, CE_60 and CE_50, taking into account the uncertainty about the levels of the 'specialist' bird species attribute:

$$U_{nj} = \beta_1 X_{SPEC_{nj}} + \beta_2 X_{GEN_{nj}} + \beta_3 X_{TIME(less)_{nj}} + \beta_4 X_{BENCHES(double)_{nj}} + \beta_5 X_{BENCHES(triple)_{nj}} + \beta_6 X^2{}_{SPEC_{nj}} + \beta_7 X^2{}_{GEN_{nj}} + \beta_8 X_{SPEC_{nj}} \cdot X_{GEN_{nj}} + \beta_9 X_{SPEC_{nj}} \cdot X_{TIME(less)_{nj}} + \beta_{10n} X_{COST_{nj}} + \varepsilon_{nj} \quad (3)$$

where

$X_{SPEC_{nj}} = \pi_1 \cdot X_{SPEC1_{nj}} + \pi_2 \cdot X_{SPEC2_{nj}}$ and,
$X^2{}_{SPEC_{nj}} = \pi_1 \cdot X_{SPEC1_{nj}} \cdot X_{SPEC1_{nj}} + \pi_2 \cdot X_{SPEC2_{nj}} \cdot X_{SPEC2_{nj}}$

for respondent n and alternative j, $X_{SPEC1_{nj}}$ is the level of the 'specialist' bird species attribute under a probability of CC-derived impacts' occurrence equal to π_1, and $X_{SPEC2_{nj}}$ is the attribute level when the probability of CC-derived impacts' non-occurrence is π_2; $X_{GEN_{nj}}$ is the level of the 'generalist' migratory bird species attribute; $X_{TIME(less)_{nj}}$ is a dummy variable taking value 1 for less than 15 minutes waiting time for a seat in an observation cabin and 0

[3] Indeed, literature talks about uncertainty when it is not possible to assign a probability to each state of nature, while it refers to risk when a probability distribution can be derived, giving information about the frequency of a set of risky outcomes (Yoe, 2012).

otherwise; $X_{BENCHES(double)_{nj}}$ and $X_{BENCHES(triple)_{nj}}$ are two dummy variables taking value 1 when the number of benches throughout the park is double and triple with respect to the current one, respectively, and 0 otherwise; and $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8$ and β_9 are the fixed attribute coefficients and β_{10n} is the individual-specific parameter for $X_{COST_{nj}}$.

The monetary value individuals assign to each attribute has been calculated by using the Hanemann (1984)'s formula for compensating variation, which provides information on the willingness-to-pay (WTP) for an increase in the attribute from the BAU situation to a policy-on context. Based on Equation 3, the WTP for a unit change in the 'specialist' bird species attribute is shown in Equation 4. :

$$\begin{aligned} WTP_{X_{SPECnj}} = & -\frac{1}{\beta_{10n}}\Big[\beta_1 \cdot (\pi_1 \cdot \left({X_{SPEC1_{nj}}}^1 - {X_{SPEC1_{nj}}}^0\right) + \pi_2 \cdot \left({X_{SPEC2_{nj}}}^1 - {X_{SPEC2_{nj}}}^0\right)) \\ & + \beta_6 \cdot (\pi_1 \cdot ({X^2_{SPEC1_{nj}}}^1 - {X^2_{SPEC1_{nj}}}^0\Big) + \pi_2 \cdot ({X^2_{SPEC2_{nj}}}^1 - {X^2_{SPEC2_{nj}}}^0) + \beta_8 \cdot {X_{GEN_{nj}}}^0 \\ & \cdot \left(\pi_1 \cdot \left({X_{SPEC1_{nj}}}^1 - {X_{SPEC1_{nj}}}^0\right) + \pi_2 \cdot \left({X_{SPEC2_{nj}}}^1 - {X_{SPEC2_{nj}}}^0\right)\right) + \beta_9 \cdot {X_{TIME(less)_{nj}}}^0 \\ & \cdot (\pi_1 \cdot \left({X_{SPEC1_{nj}}}^1 - {X_{SPEC1_{nj}}}^0\right) + \pi_2 \cdot \left({X_{SPEC2_{nj}}}^1 - {X_{SPEC2_{nj}}}^0\right))\Big] \end{aligned} \quad (4)$$

where superscripts [1] and [0] respectively indicate the level of the attribute after the change and in the BAU scenario.

4. Choice experiment results

After having eliminated the invalid and protest questionnaires[4] and taking into account each respondent faces 6 choice sets, the RPL models in CE_80 and CE_60 have been estimated by using 1,734 and 1,746 observations, respectively. Table 5 shows the results from both models together with those in REF_CE:

Table 5. Results from RPL models in REF_CE, CE_80 and CE_60[a]

	REF_CE		CE_80		CE_60	
Variables	**Coeff.**	***Std. error***	**Coeff.**	***Std. error***	**Coeff.**	***Std. error***
Fixed parameters						
X_{SPEC}	2.113***	*0.286*	1.956***	*0.181*	1.613***	*0.180*
X_{GEN}	1.245***	*0.236*	0.568***	*0.177*	1.729***	*0.188*
$X_{TIME(less)}$	0.455***	*0.139*	1.118***	*0.118*	0.150	*0.109*
$X_{BENCHES(double)}$	0.584***	*0.150*	0.116	*0.109*	0.600***	*0.125*
$X_{BENCHES(triple)}$	0.276	*0.173*	0.838***	*0.140*	0.274*	*0.140*
X^2_{SPEC}	-0.780***	*0.274*	-1.567***	*0.236*	-1.841***	*0.249*
X^2_{GEN}	-0.758***	*0.255*	-0.968***	*0.256*	0.685***	*0.226*
X_{SPEC} x X_{GEN}	-0.290*	*0.165*	-0.998***	*0.151*	-1.097***	*0.165*
X_{SPEC} x $X_{TIME(less)}$	-0.684***	*0.167*	-1.901***	*0.173*	-0.075	*0.215*
Random parameters[b]						
X_{COST}**_mean**	1.371***	*0.065*	1.087***	*0.073*	0.996***	*0.076*
X_{COST}**_std. deviation**	0.718***	*0.043*	-0.861***	*0.053*	0.966***	*0.061*
Log-likelihood	-1,050.601		-1,061.169		-1,183.264	
Observations	1,788		1,734		1,746	
N	298		289		291	

[a] ***Significant at 1% level; **Significant at 5% level; *Significant at 10% level.

[b] Coefficients of the normal distribution associated with the lognormal one.

[4] Surveys were considered to be invalid when some missing responses were detected in the section concerning the choice of the alternatives due to the respondent's lack of cooperation or when the surveyor considered the respondent was insincere. Protests included those questionnaires in which the choice of the BAU alternative was motivated by one of the following reasons: "I don't perceive any environmental problem to justify extra management efforts", "I am already paying for wetland's conservation", "Others should pay" and "I don't trust the local authorities".

According to the results in Table 5, individuals' preferences change when the uncertainty inherent around CC-derived impacts is considered in the analysis (CE_80 and CE_60). We drew this conclusion after having performed the Swait and Louviere (1993) test, which showed that differences in parameters were due to changes in preferences rather than scales.[5] Thus, when comparing the coefficients estimated in CE_80 and CE_60 with those derived under the assumption that CC-derived impacts occur with certainty within a time period of 10 years (REF_CE), it can be observed that, while maintaining the sign and significance in most of cases, the value of the attribute coefficients changes in all the scenarios. As the only difference among the three CEs is the probability of occurrence of CC-derived impacts on the number of 'specialist' bird species, from now on, the analysis will be only focused on this uncertain attribute.

In this sense, it can be observed that the main effect on utility of X_{SPEC} diminishes when uncertainty increases. So, while the attribute's coefficient is positive and significant in the three scenarios, it diminishes when the probability of occurrence of CC-derived impacts becomes lower (2.113>1.956>1.613). However, estimating the attribute's total impact on utility also requires the consideration of the interaction effects. In this sense, its quadratic term is significant and negative in the three models, this suggesting that the utility increases at a decreasing rate with the expected number of 'specialist' bird species. As the coefficient diminishes with uncertainty (-0.780>-1.567>-1.841), it can be said the concavity of the part-worth utility increases when the survival chances of X_{SPEC} grow. Additionally, the negative and significant coefficient of the interaction of X_{SPEC} with 'generalist' migratory bird species (X_{GEN}) indicates that visitors perceive both attributes as substitutes in the three scenarios. This means the respondents' part-worth utility associated with X_{SPEC} decreases with X_{GEN}, and vice versa. In this sense, it can be seen that the coefficient diminishes with uncertainty, this suggesting that the substitution behavior is strengthened when the probability of CC-derived impacts' occurrence becomes lower (-0.290>-0.998>-1.097). The fact that individuals are increasingly willing to trade-off X_{SPEC} for X_{GEN} might reveal their growing concern for X_{GEN} relatively to X_{SPEC}. Indeed, as impacts on 'generalist' migratory bird species are considered certain in the three scenarios, a decrease in the probability of CC-derived impacts on 'specialist' bird species could make individuals perceive the former as a more endangered type of species.

Likewise, visitors seem to value less the 'specialist' bird species attribute under a reduction in the waiting time, this showing again a substitution pattern between both attributes. Put another way, if the number of minutes individuals have to wait for a seat in an observation cabin is viewed as an indicator of congestion levels, then high congestion complements the value assigned to an increase in the number of 'specialist' bird species. This could be explained by the fact that the overall chances of viewing all types of birds from the observation cabins are reduced due to the higher number of visitors and the longer waiting time. In this context visitors could be prioritizing seeing a 'specialist' bird species over other types of species. However, this only happens in REF_CE and CE_80, as waiting time is non-significant in CE_60. Taking into account both the increasing number of visitors to S'Albufera and the importance of congestion issues during the summer in tourism destinations like Mallorca, which S'Albufera wetland belongs to, this information becomes policy relevant.

To better interpret these results, Table 6 shows the number of X_{SPEC} maximizing individuals' part-worth utility associated with X_{SPEC} in REF_CE, CE_80 and CE_60, under different levels of $X_{TIME(less)}$ and X_{GEN}:

Table 6. Part-worth utility maximizing number of X_{SPEC} in REF_CE, CE_80, CE_60 for different levels of $X_{TIME(less)}$ and X_{GEN}[a]

	$X_{TIME(less)}$=0			$X_{TIME(less)}$=1		
X_{GEN}	REF_CE	REF_80	REF_60	REF_CE	REF_80	REF_60
-10	+16	+9	+7	+11	+3	+7
0	+14	+6	+4	+9	+0	+4
+5	+13	+5	+3	+8	-1	+3

[a]Partworth utility maximizing number of X_{SPEC} is reported as a variation with respect to current level.

[5] The null hypothesis of scale parameters' equality across the models could not be rejected at 1% level.

Overall, visitors would maximize their utility under an increase in the number of 'specialist' bird species with respect to the current level. In specific, a higher increase in X_{SPEC} would be required under certainty rather than uncertainty of CC impacts' occurrence. This reflects the idea that, in the face of lower probability of CC impacts and higher chances that X_{SPEC} will at least maintain their number under current efforts, visitors would put less emphasis on conserving additional species with respect to the present level. Utility-maximizing number of X_{SPEC} was also found to depend on the level of X_{GEN} and $X_{TIME(less)}$. In the face of an increasing availability of X_{GEN}, individuals would demand a lower increase in X_{SPEC}, given the substitutability between these attributes. This was especially true under uncertainty, reinforcing the idea that visitors showed a higher rate of substitution between X_{GEN} and X_{SPEC} when the probability of CC impacts on 'specialist' bird species decreased. Similarly, a lower increase in X_{SPEC} would be required under a reduced congestion, this reflecting the substitution pattern between X_{SPEC} and $X_{TIME(less)}$ identified in all scenarios, except in CE_60.

Following Equation 4, the mean marginal value of X_{SPEC}, that is, the WTP for a unit increase in the attribute from the BAU (policy-off) context, has been calculated for the three scenarios. The BAU level has been considered for the interacting attributes. Additionally, to examine if the differences in mean marginal values are statistically significant, the Poe et al. (2005)'s test has been conducted. This has been performed by considering simulated vectors of the mean marginal WTP values in REF_CE, CE_80 and CE_60, obtained through the bootstrapping technique (Hole et al. 2007) based on 1,000 replications of the underlying model and, hence, of the estimation of mean marginal WTPs. Through this test, it has been possible to calculate confidence intervals for the differences between all elements of one mean marginal WTP vector (vector 1) and all elements of a second mean marginal WTP vector (vector 2). An entirely positive or negative confidence interval indicates significant differences in the mean marginal WTP values. Specifically, if the confidence interval is entirely positive, this suggests that the mean marginal value in vector 1 is significantly higher than that in vector 2, and vice versa when it is entirely negative. Table 7 reports the mean marginal values together with the results from the Poe et al. (2005)'s test for each pair comparison:

Table 7. Mean marginal value[a] of X_{SPEC} and results from the Poe et al. (2005)'s tests[b] for REF_CE, CE_80 and CE_60

	Test 1		Test 2		Test 3	
X_{SPEC}	REF_CE	CE_80	CE_80	CE_60	REF_CE	CE_60
Mean marginal value	1.31	2.43	2.43	2.75	1.31	2.75
Standard deviation	(1.12)	(2.21)	(2.21)	(3.29)	(1.12)	(3.29)
Interval	[0.54;2.37]***		[-1.03;1.41]		[0.65;2.61]***	

[a]Mean values over 298 individuals in REF_CE, 289 in CE_80 and 291 in CE_60.
[b]***Significant difference in the value at the 1% level.

According to Table 7, the mean marginal value of X_{SPEC} increases with uncertainty. This is shown in Figure 2, which plots the mean marginal value of X_{SPEC} for REF_CE, CE_80 and CE_60:

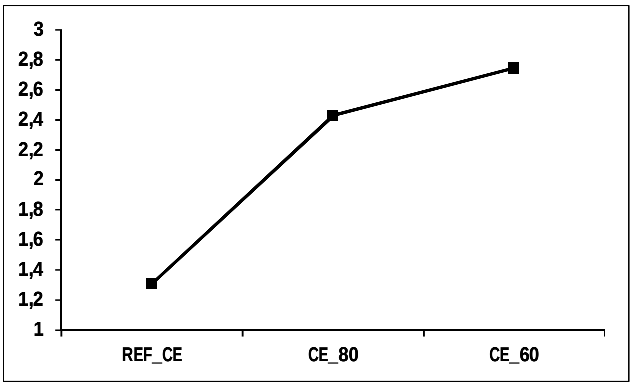

Figure 2. Mean marginal value of X_{SPEC} for REF_CE, CE_80 and CE_60

As shown in Figure 2, visitors are willing to pay more for a unit increase in the expected number of 'specialist' bird species from the BAU levels when the CC-derived impacts are uncertain. Indeed, the mean marginal value in REF_CE is statistically different from that in the two uncertain scenarios (CE_80 and CE_60). However, according to the Poe et al. (2005)'s tests, individuals are insensitive to the level of uncertainty, as the difference in the mean value in CE_80 and CE_60 is statistically equivalent. This seems to suggest that what matters to them is only to pass from certain to uncertain scenarios regardless of their associated probability.

To test for the robustness of this statement, a sensitivity analysis for the mean marginal value of X_{SPEC} has been conducted. Table 8 reports the mean marginal value of X_{SPEC} under all the levels of $X_{TIME(less)}$ and X_{GEN}, including the BAU ones as in Table 7. Note that information about the significance of the difference in the mean marginal values among all scenarios is also given:

Table 8. Mean marginal value of X_{SPEC} for different levels of $X_{TIME(less)}$ and X_{GEN}

	$X_{TIME(less)}=0$			$X_{TIME(less)}=1$		
X_{GEN}	**REF_CE**	**CE_80**	**CE_60**	**REF_CE**	**CE_80**	**CE_60**
-10	1.31^{ac}	2.43^{a}	2.75^{c}	$1.08^{a'c}$	$1.56^{a'b}$	2.75^{bc}
0	1.21^{ac}	1.97^{a}	2.11^{c}	0.98^{c}	1.10^{b}	2.11^{bc}
+5	$1.16^{a'c'}$	$1.74^{a'}$	$1.79^{c'}$	0.93^{c}	0.87^{b}	1.79^{bc}

$^{a,a'}$Significant difference in the value in REF_CE and CE_80 at 1% and 5% level, respectively.
$^{b,b'}$Significant difference in the value in CE_80 and CE_60 at 1% and 5% level, respectively.
$^{c,c'}$Significant difference in the value in REF_CE and CE_60 at 1% and 5% level, respectively.

As shown in Tables 5 and 6, the two substitution patterns identified in the preference analyses between 'specialist' bird species and 'generalist' migratory bird species and waiting time reduction are also observed in Table 8. Indeed, in each CE, the mean marginal value of X_{SPEC} diminishes with the number of 'generalist' migratory bird species and with a reduction in waiting time.

On the other side, results in Table 8 confirm that, when $X_{TIME(less)}=0$, the mean marginal values of X_{SPEC} in CE_80 and CE_60 are not statistically different from each other. This is so regardless of the level of 'generalist' migratory bird species. In contrast, when $X_{TIME(less)}=1$, although the values for CE_60 don't change with respect to a scenario of $X_{TIME(less)}=0$,[6] the difference in mean marginal WTP between CE_80 and CE_60 becomes significant under all levels of 'generalist' migratory bird species. However, whilst the mean marginal value of X_{SPEC} is statistically different between REF_CE, CE_80 and CE_60 under a loss of 10 'generalist' migratory bird species, it is statistically equivalent between REF_CE and CE_80 when the level of X_{GEN} is 0 or +5. This seems to suggest that visitors are more sensitive to the uncertainty levels when waiting time is lower. In fact, they tend to similarly interpret a probability equal to 100% and 80% but differently a probability equal to 100% and 60% when the change in the number of 'generalist' migratory bird species is positive.

To better interpret these results, Figure 3 shows the mean marginal values of X_{SPEC} under each level of X_{GEN} for both $X_{TIME(less)}=0$ and $X_{TIME(less)}=1$:

[6] This is because waiting time does not have any impact on individual utility (see Table 5).

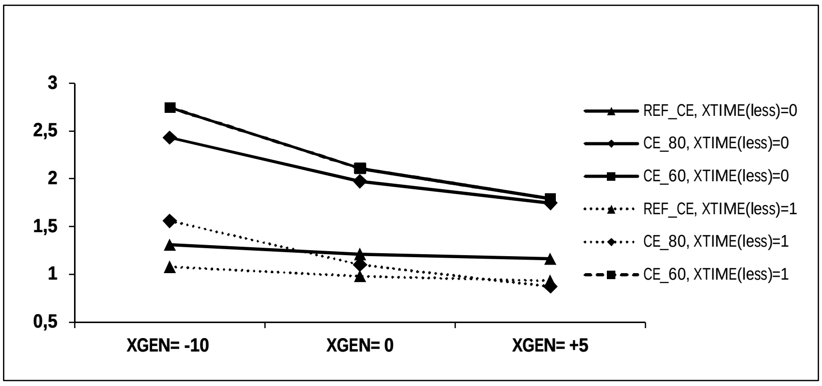

Figure 3. Mean marginal value of X_{SPEC} under each level of X_{GEN} for $X_{TIME(less)}$=0 and $X_{TIME(less)}$=1 in REF_CE, CE_80 and CE_60

4.1. Risk analysis results

Whatever analysis about the sensitiveness of WTP to different uncertainty levels cannot be undertaken without considering individuals' attitude towards risk. As explained in Section 3.1.1, risk attitude analysis has been conducted by comparing REF_CE and CE_50. Table 9 reports the estimation results between REF_CE and CE_50:

Table 9. Results from RPL models in REF_CE and CE_50[a]

	REF_CE		CE_50	
Variables	**Coeff.**	***Std. error***	**Coeff.**	***Std. error***
Fixed parameters				
X_{SPEC}	2.113***	*0.286*	1.763***	*0.266*
X_{GEN}	1.245***	*0.236*	-0.059	*0.177*
$X_{TIME(less)}$	0.455***	*0.139*	0.373***	*0.106*
$X_{BENCHES(double)}$	0.584***	*0.150*	0.728***	*0.132*
$X_{BENCHES(triple)}$	0.276	*0.173*	-0.000	*0.134*
X^2_{SPEC}	-0.780***	*0.274*	-0.292	*0.244*
X^2_{GEN}	-0.758***	*0.255*	-1.345***	*0.241*
X_{SPEC} x X_{GEN}	-0.290*	*0.165*	-0.672***	*0.138*
X_{SPEC} x $X_{TIME(less)}$	-0.684***	*0.167*	-0.531***	*0.169*
Random parameters[b]				
X_{COST}**_mean**	1.371***	*0.065*	0.822***	*0.086*
X_{COST}**_std. deviation**	0.718***	*0.043*	1.083***	*0.070*
Log-likelihood	-1,050.601		-1,178.195	
Observations	1,788		1,788	
N	298		298	

[a] *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.
[b] Coefficients of the normal distribution associated with the lognormal one.

The EU theory determines that if individuals prefer more an uncertain outcome than the same outcome achieved with a probability equal to 100%, then they are risk-lovers; if they prefer more the certain outcome, they are risk-averse; and if they are indifferent, they are risk-neutral. This suggests we could determine the risk attitude of visitors to S'Albufera by calculating, and comparing, the part-worth expected utilities associated to X_{SPEC} in CE_50 and REF_CE. However, given the results from the Swait and Louviere (1993)'s test show both models cannot be compared due to scale differences, this comparison is not possible and mean marginal values for X_{SPEC} have been considered instead.

Table 10 shows the mean marginal values for X_{SPEC}, providing information about the results from the Poe et al.

(2005)'s test. In the calculation of the mean marginal WTP, the BAU levels have been assumed for the interacting attributes ($X_{TIME(less)}$ and X_{GEN}):

Table 10. Mean marginal value[a] of X_{SPEC} and results from the Poe et al. (2005)'s test[b] for REF_CE and CE_50

X_{SPEC}	REF_CE	CE_50
Mean marginal value	1.31	1.88
Standard deviation	(1.12)	(2.65)
Interval	[0.07; 1.34]*	

[a]Mean attribute values over 298 individuals.

[b*]Statistically significant difference in the value at 10% level.

Table 10 shows that the mean marginal value of X_{SPEC} in CE_50 is statistically higher than that in REF_CE. As in both CEs individuals have chosen among alternatives reporting the same expected attribute levels, the only difference being the probability of CC-derived impacts' occurrence, this finding indicates a risk-loving attitude. This could be explained by the consideration of inherent uncertainty in the CE design, which forces the analyst to include information about all the states of nature and their associated probabilities not only in the policy-off context (BAU option) but also in the policy-on one (policy options). Therefore, individuals could be showing a loving attitude toward the fact of being given information about the inherent uncertainty effects on the policies' effectiveness. Results in Table 8 seem to confirm this. The comparison of the WTP values between REF_CE, CE_80 and CE_60 shows, on average, that individuals are better-off under uncertain rather than certain scenarios, becoming sensitive to different uncertainty levels only when congestion diminishes. So, our risk-loving individuals could be valuing positively the higher amount of information they are given in the choice sets due to the major realism it provides to the valuation exercise.

5. Discussion and conclusions

With a focus on wetland adaptation to climate change, this study has investigated the relevance of preference analysis for environmental policy-making in the presence of inherent uncertainty. In other words, it has examined whether the uncertainties around the effectiveness of an environmental policy due to the randomness of natural processes (Thom et al. 2004) have an effect on the policy's social benefits and, consequently, on the policy's social return. In this sense, it provides evidence of the importance of conducting welfare-based analyses to inform policy makers in contexts characterized by inherent uncertainties that make unpredictable the policy results. Indeed, it gives information on how the social values attributed to a series of environmental outcomes that could be achieved *under* inherent uncertainty scenarios depend on the level of uncertainty, which contributes to improve policy design focusing on adaptation to unavoidable, uncontrollable circumstances. This information can give guidance to policy makers on how to build a greater adaptive capacity to exert more control over the impacts of unpredictable events on policy effectiveness (Abbott, 2005).

Despite the relevance of the issue, and the increasing claims for considering inherent uncertainty in environmental policy design, the valuation literature has paid little attention to it. The difficulty of conceptualizing and treating an uncertainty of unmeasurable and unpredictable nature helps explain the scarce research on the issue (Johansson 1989; Cameron 2005; Viscusi and Zeckhauser 2006). In this context, it has been common practice the use of subjective probabilities to reflect the uncertainty around the timing and magnitude of future environmental states. Asking individuals about the probabilities they would assign to given environmental scenarios has been argued to be particularly suitable to handle situations where these probabilities are not known by the analyst (Dubois and Prade 2009). However, basing the definition of inherent uncertainty-related outcomes on individuals' perceptions does not seem to be the most appropriate way to deal with this type uncertainty. Indeed, if it is random and unpredictable by definition, it should not be determined by individuals.

To better represent the exogenous dimension of inherent uncertainty, we have used an alternative approach based on the use of objective rather than subjective probabilities. In this sense, from the whole range of probabilities (0% to 100%), we have randomly chosen the values of 80% and 60% to define the probability of occurrence of CC-derived impacts and the associated policy outcomes. On the one hand, this has allowed us to make clear to respondents the unpredictable nature of the uncertainty, as suggested by Glenk and Colombo (2011). Indeed, using arbitrary probability values can be viewed as equivalent to recognizing the impossibility of assigning specific probabilities to each possible outcome and, hence to assume inherent uncertainty. On the other one, this has permitted to conduct the analysis under the EU framework, which assumes individuals display preferences over outcomes linked to probabilities rather than over the probabilities themselves. In this sense, we can say that recent evidence from laboratory experiments against EU theory (Bocquého et al. 2014; Buchholz and Schymura, 2011; Conte and Hey 2013) does not apply to this research as careful pretesting at an initial stage of the study ensured a good understanding by respondents of the probability scenarios. Besides, no *low probable, high impacts* contexts were considered. This way we have avoided problems of ambiguity and indeterminateness usually associated with the definition of probabilities, which has made the EU framework an appropriate one for the analysis (Shaw and Woodward, 2008).

Our findings show that, on average, individuals are better-off under uncertain rather than certain scenarios, becoming sensitive to different uncertainty levels only when congestion diminishes. The risk attitude analysis in section 4.1 reinforces this conclusion as individuals are found to choose among alternatives acting as risk-lovers rather than risk-averse. Put another way, the WTP for a unit increase in the level of an environmental good subject to the effects of inherent uncertainty (the number of 'specialist' bird species) is statistically lower when these effects occur with certainty (when the probability of occurrence of the CC-derived impacts is equal to 100%). A priori, one could think these results contradict those from the main approach in the valuation literature dealing with uncertainty issues. Indeed, on the basis individuals are found to be risk-averse, these studies suggest the social desirability of uncertainty reducing actions. The welfare gains associated with certain rather uncertain environmental scenarios allow researchers to advocate for the need of increasing knowledge on uncertainty issues in an attempt to reduce uncertainty and hence improve policies' effectiveness. Therefore, should a risk-loving attitude be viewed as a vote against this need? The answer is no.

As discussed in section 4.1, a risk loving attitude could indicate individuals value positively the inherent uncertainty information they are given in the choice sets due to the major realism it provides to the valuation exercise. Indeed, the consideration of inherent uncertainty in the CE design forces the analyst to also include information about the states of nature and their associated probabilities in the policy-on context. In fact, assuming the outcome resulting from policies applied in uncertain, environmental settings is unique with a probability equal to 100% is not realistic as it implicitly assumes the policy can control for the inherent uncertainty. But, by definition, this is not possible. Thus, our findings of a loving attitude toward being informed about the inherent uncertainty effects also suggest a social desirability of actions aimed at increasing uncertainty-related knowledge in an attempt to improve policies' effectiveness. As individuals are better-off if they are better informed, more information on the issue is needed. And gaining knowledge through research, education and training to better inform respondents has a positive impact on policy's performance even if inherent uncertainty cannot be controlled for. Indeed, this information can better inform policy makers about how to efficiently build a greater adaptive capacity which will allows them to exert more control over the impacts of unpredictable events on policy effectiveness.

Despite numerous research questions still remain unanswered, the results of this study add to the emerging literature dealing with uncertainty issues. They not only provide evidence of the sensitivity of the WTP to uncertainty but also they do it in a more realistic scenario in which the effects of uncertainty on the policy outcomes have also been considered. Put another way, they contribute to raise public awareness on the issue (Young, 2001; Berkes, 2007; Ascough II et al., 2008; Weitzman, 2013; Heal and Millner, 2014) in a context where the recent efforts to incorporate uncertainty into the environmental valuation framework have assumed that policy-makers only face knowledge-based uncertainty.

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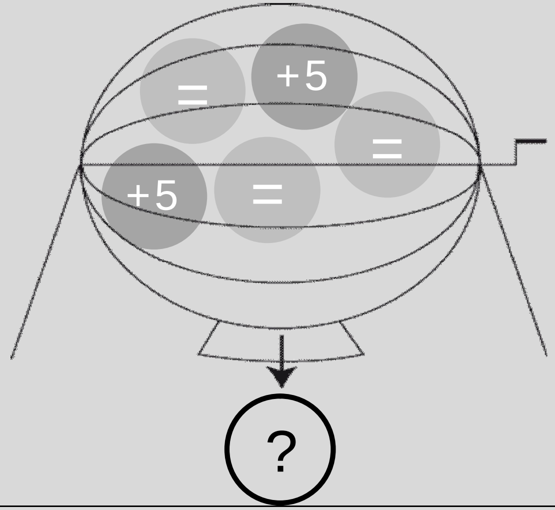
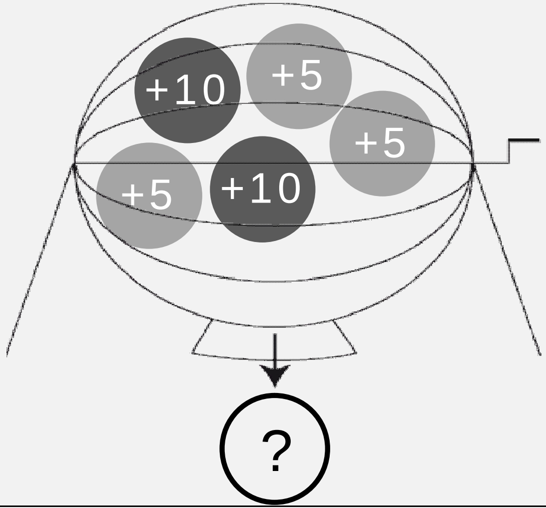
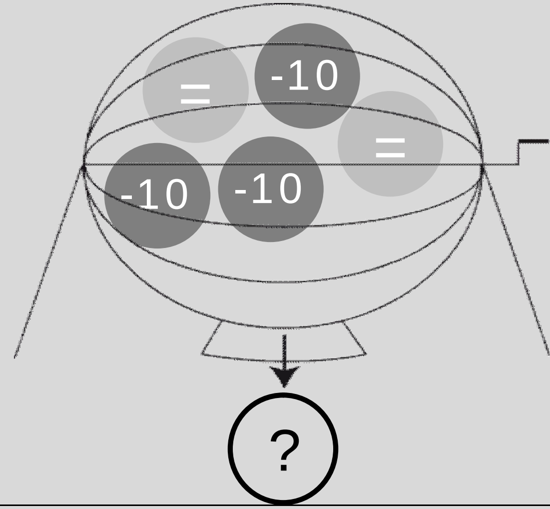
FIGURES 1a and 1b

ATTRIBUTES	POLICY A	POLICY B	NO POLICY INTERVENTION (C)
'SPECIALIST' BIRD SPECIES	+5 Increase the current number by 5	= Keep the current number	-10 Decrease the current number by 10
'GENERALIST' MIGRATORY BIRD SPECIES	+5 Increase the current number by 5	+5 Increase the current number by 5	-10 Decrease the current number by 10
WAITING TIME	≃3' Wait about 3 minutes for a seat in observation cabins	≃7' Wait about 7 minutes for a seat in observation cabins	≃15' Wait about 15 minutes for a seat in observation cabins
REST-STOP BENCHES	x2 Double the current number throughout the park	x3 Triple the current number throughout the park	= Keep the current number
ENTRANCE FEE	€16	€8	€0
ATTRIBUTES	POLICY A	POLICY B	NO POLICY INTERVENTION (C)

'SPECIALIST' BIRD SPECIES			
'GENERALIST' MIGRATORY BIRD SPECIES	= Keep the current number	-10 Decrease the current number by 10	-10 Decrease the current number by 10
WAITING TIME	≃15' Wait about 15 minutes for a seat in observation cabins	≃15' Wait about 15 minutes for a seat in observation cabins	≃15' Wait about 15 minutes for a seat in observation cabins
REST-STOP BENCHES	x3 Triple the current number throughout the park	x2 Double the current number throughout the park	= Keep the current number
ENTRANCE FEE	€16	€24	€0