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Anna Bartczak, Susan Chilton
Jürgen Meyerhoff

The Impact of Individual Risk Preferences on Valuing Preservation of Threatened Species: An Application to Lynx Populations in Poland

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The Impact of Individual Risk Preferences on Valuing Preservation of Threatened Species: an Application to Lynx Populations in Poland

ANNA BARTCZAK
Faculty of Economic Sciences,
Warsaw Ecological Economics Center
University of Warsaw
e-mail: bartczak@wne.uw.edu.pl

SUSAN CHILTON
Newcastle University Business School
e-mail: s.m.chilton@newcastle.ac.uk

JÜRGEN MEYERHOFF
Technische Universität Berlin,
Institute for Landscape and Environmental Planning
e-mail: juergen.meyerhoff@tu-berlin.de

Abstract

A recent innovation in environmental valuation surveys has been to acknowledge the inherent uncertainties surrounding the provision of environmental goods and services and to incorporate it into non-market survey designs. So far, little is known about how people assimilate and respond to such uncertainty, particularly in terms of how it affects their stated valuations. In this paper we focus on the impact of risk preferences on people's investments in environment. Individual risk preferences are elicited through a standard, incentivized multiple price list mechanism and used as a independent variable in the analysis of a choice experiment valuing the preservation of two threatened lynx populations in Poland. We find that risk-seeking respondents were more likely to choose the status quo option, which was the riskiest option in terms of the survival of the two distinct lynx populations. Risk seekers revealed also a significantly lower willingness to pay for lynx preservations.

Keywords:
choice experiment, environmental good, lottery experiment, lynx preservation, risk preferences, status quo effect

JEL:
Q23, Q51, Q56, Q57

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1. Introduction

Due to limited knowledge of natural processes and the fact that improvements in environment involve often very long time horizons the outcomes can entail substantial uncertainty. Stated preference environmental valuation studies increasingly recognize and attempt to incorporate such uncertainty. For example, to deal with limited knowledge in the case of species preservation, environmental outcomes are often presented to respondents as uncertain *per se*. The outcomes are described as changes in the chances of a populations' survival, most commonly defined as an increase in the number of species by X%, in a certain period (see Richardson and Loomis, 2009). The other source of uncertainty is related to delivery. Supply uncertainty in respect of long-term projects can arise for a number of reasons, such as the limited reliability of institutions responsible for project implementation or from possible changes to the political, social and economic environment (see e.g. Rigby et al., 2011, Rolfe and Windle, 2010, Glenk and Colombo, 2011).

These approaches constitute a significant methodological advance on the past, where environmental outcomes were - explicitly or implicitly - presented as certain. However, how respondents respond to and assimilate this uncertainty, particularly in respect of how it affects their values, remains an open question. If we, like other practitioners, are willing to assume that respondents comprehend the scientific uncertainty sufficiently well to answer to our surveys, then we can begin to address this issue.

In this paper we focus on the impact of risk preferences on values, although we acknowledge that many other factors must play a part. Risk preferences have been shown to influence behavior in a number of other domains where uncertainty is a key feature of future outcomes e.g. health protection, financial investments, job changes or driving behavior (i.e. Anderson and Mellor 2008; Kimball et al. 2007; Hakes and Viscusi, 2007; Weber et al., 2002).

The main objective of the present paper is to examine the impact, if any, of individual risk preferences on estimated willingness to pay for lynx preservation in Poland based on the results from a choice experiment. The study consisted of two main parts. The first part was as a choice experiment designed to value preservation of the two main lynx populations in Poland: the Lowland population that occupies the north-east part of the country and the Carpathian located in the south. Both populations are exposed to a high risk of becoming extinct. Mostly, this is the result of the rapid growth of transport infrastructure and insufficient protection programs. The outcomes of conservation programs presented in the CE were specified as uncertain which reflects scientific reality. To show in CE inherent uncertainties surrounding the provision of the good we adopted the measure of risk extinction from the Red list of threatened species by the International Union for Conservation of Nature (IUCN). Using this approach, we respected the fact that the chances of survival were positively correlated with the degree of intervention but were able to avoid the need to provide numerical probabilities of survival or quantitative information on the size of the populations concerned.

The other part of the survey was devoted to eliciting respondents' risk preferences. We utilised a standard multiple price listing (MPL) originally proposed by Binswanger (1980) and later modified by Holt and Laury (2002). A major advantage of this approach, in contrast to many other elicitation methods, is that it allows the analyst to identify whether respondents are rather risk seekers, or risk lovers, or people with risk-neutral preferences, rather than simply ranking these preferences. Additionally, Holt and Laury (2002) lottery choice experiments are relatively easy to explain, transparent, incentive-compatible (there is real money at stake) and they are context-free, thus avoiding potential framing effects such as those that arise in buying or selling frameworks.

The elicited in an experimental way individual risk preferences were then used as a determinant of respondents preferences towards lynx preservation in Poland. After testing various model specifications risk preferences were incorporated via an interaction effect with the status quo (SQ) option into the econometric models estimating the WTP values for increasing the chances of survival of the lynx populations.

This article builds on prior studies that investigate the association between individual risk preferences and investments in an environmental good. Only a few prior studies before tested whether risk preferences measured in an experimental way were linked with real risky behavior. Anderson and Mellor (2008), for example, showed that individuals who are more risk averse were less likely to smoke and more likely to wear seat belts. Elston et al. (2005) reported that full-time entrepreneurs were less risk averse than non-entrepreneurs, and that part-time entrepreneurs were more risk averse than non-entrepreneurs. Lusk and Coble (2005) found that risk preferences were significant determinants of acceptance of genetically modified food. Meanwhile, Olbrich et al. (2011) reported in their study that adult farmers in Namibia self-selected themselves onto farms according to their risk preferences i.e., those with lower risk aversion were found on farms with higher environmental risks. All of these studies, however, considered private goods. To our knowledge this is the first empirical investigation of the relationship between incentivized individual risk preferences and a uncertain public good and the first study assessing the impact of incentivized individual risk preferences on environmental valuations based on a choice experiment.

We find that risk seekers are (i) more likely to choose the status quo i.e. the 'do-nothing' option for no additional cost option, where in common with many environmental programs the SQ is actually the riskiest from the perspective of the environmental good; (ii) appear to suffer a lower welfare loss from (possible) species extinction than other respondents, reflected in a lower marginal willingness to pay (WTP) for lynx preservation. Risk preferences were in fact incorporated via an interaction effect with SQ option into the econometric models estimating WTP values for increasing survival chances of the lynx populations. A stylized fact within choice experiments is over-statement of the status quo relative to what might be predicted (see e.g. Scarpa et al., 2005 or Meyerhoff and Liebe, 2009) but our findings raise an interesting question as to how much of the SQ 'bias' is simply a reflection of real (i.e. risk) preferences, at least for some respondents.

The remainder of the article is structured as follows: Section 2 summarizes the present situation of lynx preservation in Poland, while Section 3 reports the design and administration of the choice experiment, the mechanism used to elicit individual risk preferences and the resulting data sets. Section 4 presents the results of the econometric analysis of responses. Finally, Section 5 discusses these results in the context of this study but also offers some general observations on the implications for future choice experiment practice when uncertain outcomes are a significant feature.

2. Situation of lynx in Poland

The Eurasian lynx (*Lynx lynx*) is the third largest predator in Europe, after the brown bear and the wolf. They live in forests in low-density populations occupying large territories. The animals prey at night, mainly on small ungulates and hares. Encounters between lynx and humans in the wild are highly unlikely and, further, they pose no threat to human lives (von Arx et al., 2004).

Poland is one of the few European countries where lynx have survived in the wild. However, the number of Polish lynx living in the wild has decreased to a third over the last 20 years and is estimated to be about 180-200 individuals in total (Jędrzejewski et al. 2002; von Arx et al. 2004). Although lynx have been officially protected in Poland since 1995, little has been done so far to ensure the longer term survival of the species (Niedziałkowska et al. 2006). In general, their current status in Poland is considered as 'near threatened' according to the IUCN Red List of threatened species.

There are two main lynx populations in Poland: the Lowland population in the northeast and the Carpathian population in the south of the country. Both populations live in border regions and are part of two major populations of this species in Europe. Apart from Poland the Carpathian Eurasian lynx population occurs in the Czech Republic, Slovakia and Ukraine, whereas the Lowland lynx population is present in Baltic and Scandinavian countries. While the lynx is in general considered as a near threatened species in Poland, the risk of extinction differs for the Lowland and the Carpathian population. The Polish Carpathian population is larger in number and more widely distributed than the Lowland population and is estimated at about 100 animals. Existing migration corridors allow for the exchange of the Carpathian lynx between countries. Meanwhile, the Lowland lynx population is estimated at about 60 animals and occupies a highly fragmented habitat[1]. This group is more isolated from lynx populations in other countries. These factors contribute to a higher risk of extinction of the Lowland lynx in comparison to the Carpathian population (von Arx et al., 2004).

Niedziałkowska et al. (2006) identify the fragmentation of forest habitats as a major threat for the survival of the lynx populations in Poland. Over the last two decades the number of cars in Poland doubled, the motorway network has increased three times (GUS, 2011) and the development of transportation infrastructure, mainly highways, continues at a fast pace. As construction projects frequently neglect the need for sufficient number, size and proper location of wildlife passes across the highways this development contributes to habitat fragmentation and further isolation of source populations of large carnivores (Niedziałkowska et al., 2006). Other threats to lynx populations occur as a result of current forest management i.e., afforestation of open spaces and failing to leave enough deadwood in forests (Schmidt 2008). Such changes in forests disturb the lynx's hunting and living conditions. Additionally, game hunting and poaching by humans cause food scarcity. If these impacts on habitat conditions continue, it is anticipated that Polish lynx population may be seriously threatened in the next decades (Niedziałkowska et al., 2006) .

3. Survey design and methodology

3.1. Survey structure

The valuation survey consisted of six parts. Part 1 presented general information concerning forests in Poland and questions about respondents' forest-recreation patterns. Part 2 provided general information on the lynx population in Europe and a more detailed description of the two lynx populations in Poland. This information included a physical description of the lynx, its habits, place of occurrence and the main threats. Then, section 3 depicted potential management actions that could increase chances of survival of the two

[1] In addition to the Lowland and Carpathian lynx populations and a few isolated individuals in the north of Poland, a group of 12-15 lynx lives in central Poland in the Kampinowski National Park. The lynx were reintroduced there in 1994. This reintroduction was debated very controversial as all the animals were born in captivity. Moreover, the group is isolated and cannot survive in the wild without human support.

main lynx populations in the country. Among those actions the most important was to create corridors and passes across roads and railway tracks enabling the lynx to migrate between forest complexes. In section 4 the choice sets were presented to respondents. Part 5 was devoted to the experimental elicitation of respondents' risk preferences. Section 6 consisted of debriefing questions to identify protest responses, and standard socio-economic questions.

3.2. CE design

The choice experiment comprises three attributes: the status of both the Lowland and of the Carpathian lynx population in 20 years from now, and the annual cost of the particular conservation program per person.[2] Following consultation with forest biologists, instead of employing the commonly used increase in the number of individuals as a measure of improved protection of the endangered species we decided to describe the status of the lynx populations in terms of its chances of survival. This form of presentation better reflects the inherent ecological uncertainty surrounding lynx survival even in the presence of intervention and is also, arguably, easier for respondents to understand than presenting chances of survival in percentages or showing different population sizes. The categories used are based on the IUCN Red List of threatened species. To make the categories clearer the official terminology was simplified slightly (see Table 1). The final category descriptions along with the current and the predicted status for both lynx populations were consulted with experts from the Institute of Nature Conservation and the Mammal Research Institute at the Polish Academy of Sciences.

Table 1. Levels of threat.

IUCN Red List*	Scale adapted for the CE
Critically Endangered (CR) - Extremely high risk of extinction in the wild.	**Critically threatened** - Extremely high risk of extinction in the wild
Endangered (EN) - High risk of extinction in the wild.	**Highly threatened** - High risk of extinction in the wild.
Vulnerable (VU) - High risk of endangerment in the wild.	**Moderately threatened** - Moderate risk of extinction in the wild.
Near Threatened (NT) - Likely to become endangered in the near future.	**Low threat level** - Low risk of extinction in the wild.
Least Concern (LC) - Lowest risk. Does not qualify for a more at risk category.	**Stable** - Negligible risk of extinction in the wild.

Note: * The IUCN Red List includes two additional categories: extinct in the wild (EW) and extinct (EX), which were not included in the valuation survey, as they were not seen as necessary for the purpose of our study.

For the purposes of the CE, the future status of the Lowland population could take one of five levels (from critically threatened to stable), while for the Carpathian population four attribute levels were used (from highly threatened to stable). The payment vehicle was a tax

[2] The design of the choice experiment follows Lew et al. (2010) to some extent. They investigate the public's preferences for enhancements to the protection of the western stock of Steller sea lions (Eumetopias jubatus).

that would go to a special fund established for lynx protection in Poland. Table 2 shows the full list of attribute levels in the experimental design.

Table 2. Attributes and levels in CE.

Attributes	Levels
Lowland lynx population	critically threatened (projected Status Quo), highly threatened, moderately threatened, low threat level, stable
Carpathian lynx population	highly threatened (projected Status Quo), moderately threatened, low threat level, stable
Cost per person per year[3]	0zł (projected Status Quo), 15zł, 50zł, 90zł, 150zł

The choice sets were created using a Bayesian D-efficient design with fixed priors using the NGene software. The priors were gained using the responses from focus group participants. As efficiency measure the so-called S-estimate was used (Bliemer and Rose, 2011). The final design comprised 24 choice sets that were blocked into 4 subsets. Each set comprises two policy options and a business-as-usual option. Each option describes the effect the protection measures would have on the lynx populations' chances of survival in future. Additionally, the sets provided the information about the current number of individuals of each population. To illustrate the differences between the hypothetical threat levels, colors following the idea of traffic lights are used to mark attribute levels, i.e., each attribute levels was accompanied by a pictogram of a lynx colored according to the threat level. Each respondent faced seven choice sets in total, including one with a dominant alternative; the latter choice sets are not used in the present analysis. An example choice set is presented in Figure 1.

[3] The nominal exchange rate from February 2011: 1 € = 3.9 zł

	Program A No additional protection measures Expected results in 20 years	**Program B** Additional protection measures Expected results in 20 years	**Program C** Additional protection measures Expected results in 20 years
LOWLAND LYNX POPULATION Current number: 60 animals	**CRITICALLY THREATENED** **Extremely high** risk of extinction 	**STABLE POPULATION** **Negligible** risk of extinction 	**CRITICALLY THREATENED** **Extremely high** risk of extinction 
CARPATHIAN LYNX POPULATION Current number: 100 animals	**HIGHLY THREATENED** **High** risk of extinction 	**HIGHLY THREATENED** **High** risk of extinction 	**MODERATELLY THREATENED** **Moderate** risk of extinction 
Cost per person per year	**0 zł**	**90 zł**	**90 zł**
I prefer **the most**	☐	☐	☐

Figure 1. Example choice set

3.3. Measuring risk preferences with a lottery choice task

Based on the Holt and Laury (2002) approach, individual respondents were presented with a series of ten paired lotteries). For each of the ten decisions, they were asked to choose either lottery A or lottery B. In each decision, lottery A was the safe choice and the lottery B was the risky option. The payoffs for the safe option were less variable than for the risky one. For both lotteries, in each successive row, the likelihood of receiving larger rewards increased. For the first four decisions, the expected payoff for lottery A was higher than for lottery B, while for the next six decisions lottery B had a higher expected payoff. In the last row no uncertainty was assigned to payoffs. Following Anderson and Mellor (2008), we presented payoffs that were three times higher than the Holt and Laury (2002) baseline amounts. Table 3 shows the full set of decision tasks.

Table 3. Lottery choice experiment

Decision	Lottery A	Lottery B	E(A) –E(B)
1	Receive **18zł** if dice throw is **1**. Receive **14.50zł** if dice throw is **2-10**.	Receive **34.70zł** if dice throw is **1**. Receive **0.90zł** if dice throw is **2-10**.	10.6
2	Receive **18zł** if dice throw is **1-2**. Receive **14.50zł** if dice throw is **3-10**.	Receive **34.70zł** if dice throw is **1-2**. Receive **0.90zł** if dice throw is **3-10**.	7.5
3	Receive **18zł** if dice throw is **1-3**. Receive **14.50zł** if dice throw is **4-10**.	Receive **34.70zł** if dice throw is **1-3**. Receive **0.90zł** if dice throw is **4-10**.	4.5
4	Receive **18zł** if dice throw is **1-4**. Receive **14.50zł** if dice throw is **5-10**.	Receive **34.70zł** if dice throw is **1-4**. Receive **0.90zł** if dice throw is **5-10**.	1.5
5	Receive **18zł** if dice throw is **1-5**. Receive **14.50zł** if dice throw is **6-10**.	Receive **34.70zł** if dice throw is **1-5**. Receive **0.90zł** if dice throw is **6-10**.	-1.6
6	Receive **18zł** if dice throw is **1-6**. Receive **14.50zł** if dice throw is **7-10**.	Receive **34.70zł** if dice throw is **1-6**. Receive **0.90zł** if dice throw is **7-10**.	-4,6
7	Receive **18zł** if dice throw is **1-7**. Receive **14.50zł** if dice throw is **8-10**.	Receive **34.70zł** if dice throw is **1-7**. Receive **0.90zł** if dice throw is **8-10**.	-7.6
8	Receive **18zł** if dice throw is **1-8**. Receive **14.50zł** if dice throw is **9-10**.	Receive **34.70zł** if dice throw is **1-8**. Receive **0.90zł** if dice throw is **9-10**.	-10.6
9	Receive **18zł** if dice throw is **1-9**. Receive **14.50zł** if dice throw is **10**.	Receive **34.70zł** if dice throw is **1-9**. Receive **0.90zł** if dice throw is **10**.	-13.7
10	Receive **18zł** if dice throw is **1-10**.	Receive **34.70zł** if dice throw is **1-10**.	-16.7

From the ten decisions, one was randomly selected as binding by the roll of a ten-sided die. Then, a die was thrown again to determine whether the individual received the high or low payoff from the chosen lottery. By assuming constant relative risk aversion (CRRA), the row at which an individual switched from the safe option to the risky one was used to define her risk aversion level.

The ranges of CRRA parameters can be derived from the following utility function of income:

$$U\left(Y_i^{k,j}\right) = \frac{\left(Y_i^{k,j}\right)^{1-r_i}}{1-r_i}, \qquad r_i \neq 1, \tag{1}$$

where $Y_j^{k,j}$ is the payoff in the lottery $k \in \{\text{safe option (A), risky option (B)}\}$ from outcome $j \in \{1,2\}$ that individual $i \in \{1, \dots, \mathrm{N}\}$ receives. In this formula r_i denotes the coefficient of relative risk aversion (the curvature parameter). An r_i greater than zero indicates risk-averse preferences, an r_i that equals zero – risk neutrality, and risk seeking preferences correspond to a r_i parameter lower than zero. Subjects confronted with a binary lottery are assumed to calculate the following expected utility (EU) at every decision row:

$$EU_{i,m}^k = \sum_{j=1}^{2} p_m^j \cdot U\left(Y_i^{k,j}\right), \tag{2}$$

where p_m^j denotes the probability of one of two possible risky outcomes in lottery k and in row m. In every lottery rewards are constant across rows (see table 3.).

In most cases, individuals start by choosing the safe option (lottery A) and then switch from this lottery to lottery B – and play B thereafter. In such a case, the lower limit of CRRA range is determined by equalizing the utilities from lottery A and B for the last chosen safe option, whereas the upper limit of CRRA is calculated equalizing utilities from both lotteries for the decision when the risky option is chosen for the first time. For example, for an individual who chooses the safe option in the first three decisions and then continue to play lottery B the lower limit of CRRA is calculated by solving the following equation:

$$EU_{i,3}^{A} = EU_{i,3}^{B} , \tag{3}$$

And the upper bound from equation (4):

$$EU_{i,4}^{A} = EU_{i,4}^{B} , \tag{4}$$

All ranges of CRRA parameters and corresponding lottery choice decisions are reported in table 4.

Table 4. Lottery choices and risk preferences.

Number of safe decisions (lottery A)	Range of CRRA	CRRA code
0-1	r < -0.95	Risk Seeker 3
2	-0.95 < r < 0.49	Risk Seeker 2
3	-0.49 < r < -0.15	Risk Seeker 1
4	-0.15 < r < 0.15	Risk Neutral
5	0.15 < r < 0.41	Risk Averse 1
6	0.41 < r < 0.68	Risk Averse 2
7	0.68 < r < 0.97	Risk Averse 3
8	0.97 < r < 1.37	Risk Averse 4
9-10	1.37 < r	Risk Averse 5

In some studies multiple switching behavior has been observed among participants of lottery choice experiments (see e.g. Holt and Laury, 2002, Lusk and Coble 2005, Harrison et al. 2007, Anderson and Mellor 2008, or Jacobson and Petrie 2009). For individuals who made multiple switches in our study, we followed Harrison et al. (2007), and Anderson and Mellor (2008) by determining the range of values for constant relative risk aversion. Accordingly, the first switch an individual made from the lottery A to the lottery B determined the lower limit of the range. The upper limit was determined by the last safe choice a subject made. In this approach multiple switchers are assumed to be indifferent between the options in the intermediate decisions (Harrison et al., 2007).

3.4. Econometric approach

Two econometric models were used to analyse respondents choices. The conditional logit (CL) model served as a starting point followed by the random parameter logit (RPL) allowing a test for heterogeneity of preferences. Both models are briefly introduced, starting with the CL model. In the commonly-applied random utility model the utility an individual *i* receives from choosing an alternative j at choice task t (U_{itj}) consists of a systematic component (V_{itj}) and a random error component (ε_{itj}), such that:

$$U_{itj} = V_{itj} + \varepsilon_{itj}\,, \tag{5}$$

In this function, the systematic part of the utility of alternative j is commonly assumed to be a linear function of *k* attributes, *x*, related to each of the *j* alternatives

$$U_{itj} = \sigma_i \sum_{k=1}^{K} \beta_{ik} x_{itjk} + \varepsilon_{itj}, \tag{6}$$

where β_{ik} represents the parameter weight associated with attribute *k* for respondent *i*, and σ_i is the scale parameter of the error distribution generally normalized to 1 in applications. The unobserved component ε_{itj} is assumed to be independently and identically (IID) extreme value type 1 distributed. The random parameter logit model (Hensher and Greene, 2003; Train, 2003) allows investigation of taste heterogeneity. The model is based on the assumption that parameters are randomly distributed in the population. Estimating the mean and variance of the random parameter distribution captures heterogeneity. Individuals are assumed to be draws from a taste distribution; therefore, an additional stochastic element, which may be heteroskedastic and correlated across alternatives, is introduced into the utility function, so that:

$$U_{itj} = \sigma_i \sum_{k=1}^{K} \beta_{ik} x_{itjk} + \eta_{ij} + \varepsilon_{itj}, \tag{7}$$

where η_{ij} is an additional random term with mean = 0 whose distribution over individuals and alternatives depends in general on underlying parameters and data related to individual *i* and alternative *j*. The second error term ε_{itj} has a 0 mean, is IID over alternatives and does not depend on underlying parameters or data. The random term η_{ij} can take on different distributional forms, such as normal, lognormal, uniform or triangular.

3.5. Data

Survey respondents were selected from Warsaw inhabitants. It is a quota sample representative of the Warsaw population in terms of gender, age and education. The survey was carried out in February 2011. Interviews were conducted by a professional polling agency using the computer-assisted personal interviewing (CAPI) system. In total, three hundred questionnaires were collected. The main survey was pretested in 50 face-to-face interviews of the Faculty of Economics at the University of Warsaw students.

Table 5. Descriptive statistics of the analyzed sample.

	Share	Mean	Median	Min	Max
Women	53%				
Age		46	47	20	90
Education					
- Primary	8%				
- Secondary	49%				
- High	43%				
Net monthly household income in zł		4,359	3,500	500	22,500
Net monthly individual income in zł		2,357	2,500	0	9,500

Note: The nominal exchange rate from February 2011: 1 € = 3.9 zł.

Individuals were excluded from the analysis if they chose the safe option for decision 10 in the lottery experiment or if they switched constantly between lottery A and over all 10 decisions. We interpret this as not understanding the given instruction. Additionally, respondents who always chose the most expensive alternative in the CE part were omitted. We assumed that these individuals were protesting against some aspect of the survey. This resulted in a final set of responses from 214 individuals corresponding to 1,284 observations to be analyzed.

4. Results

4.1 Risk Preference Elicitation

Out of the analyzed sample, 69% of the respondents started with option A, then switched from this option to lottery B just once and played this lottery thereafter. 31% switched back from the risky lottery B to lottery A. Holt and Laury (2002), Lusk and Coble (2005), and Anderson and Mellor (2008) report this kind of behavior as well in their lottery experiments, but the share of multiple switchers in their cases was lower, 13%, 5%, and 21%, respectively; however, the first two surveys were conducted solely among students, only the Anderson and Mellor sample comprised mostly non-student adults. In the present survey, respondents were recruited from the general public. Table 6 presents the spread of risk preferences across the sample. The risk seekers group is characterized by the lowest share of women and the highest income level. The risk averse group contains the oldest respondents and the lowest share of people with a higher level of education. This is in line with findings of some other studies. Barsky et al. (1997), Croson and Gneezy (2009), and Dohmen et al. (2011) showed that women and older people, typically, were more risk averse then men and younger individuals. Guiso and Paiella (2008) found that risk tolerance was an increasing function of individuals' resources. The results of the Galarza (2009) study indicate that more educated people were less risk averse.

In the current study risk seekers comprise 24% of the analyzed sample. This share seems to be relatively high compared with findings from other studies where risk preferences were elicited in an experimental setting (e.g. Holt and Laury, 2002 classified 8% of their sample to a risk seeking group, while the corresponding figures for Anderson and Mellor and Coble and Lusk were 14% and12% respectively). However, there are also examples in the literature of higher estimates. Reynaud and Couture (2010), for example, when applying the Holt and Laury (2002) lottery identified 25% risk seekers among French farmers.

Table 6. Risk preferences groups in the analyzed sample.

	Risk seekers (24%)		**Risk neutral** (40%)		**Risk averse** (36%)	
	Share	Mean	Share	Mean	Share	Mean
Women	45%		55%		55%	
Age		47		43		48
Education						
- Primary	11%		6%		7%	
- Secondary	45%		46%		54%	
- High	44%		48%		39%	
Net monthly household income in zł		5,198		4,596		3,595
Net monthly individual income in zł		2,774		2,410		2,008

4.1 Choice Experiment

Table 7 reports the parameter estimates of both the CL and the RPL model. Risk preferences enter both models via an interaction effect with the alternative specific constant (ASC) indicating the status quo. Other interactions with the attributes were tested but were not statistically significant. In the case of the RPL model, all attributes, except cost, were specified to follow a normal distribution, as it is expected that respondents will deviate from the mean in both directions. All attribute levels are effect coded. In the RPL model the choice probabilities were approximated by simulations based on 300 Halton draws.

Overall, both models are highly significant while the RPL model shows based on the model log-likelihood a much better fit to the data. The highly significant standard deviations for all but one attribute (Carp_mod) indicate that substantial unobserved heterogeneity with respect to the preferences for the protection levels is present. The CL model shows a similar preference structure to the RPL model in terms of mean effects. In both models, the cost parameter is negatively statistically significant, and the negative parameter for the ASC indicates clearly that on average respondents would benefit from moving away from the current situation. Additionally, the parameter estimates for the two highest protection levels – low threat and stable population – are positive and significant for both populations. However, in the CL model, the estimate for a stable Carpathian population is statistically significant only at the 10% level.

Table 7. Estimation results.

Variable	CL	RPL (Panel)
Mean		
SQ_ASC	-1.2087***	-1.7241***
SQ_ASC_riskse	0.9608**	1.0241**
Lowl_high	-0.1184	-0.1868
Lowl_mod	-0.0086	0.2338
Lowl_low	0.5311***	1.0161***
Lowl_stab	0.4699***	0.7366***
Carp_mod	-0.0004	0.0794
Carp_low	0.2336***	0.3220***
Carp_stab	0.1474*	0.3928***
Cost	-0.0087***	-0.0140***
Standard deviation		
Lowl_high		0.8103***
Lowl_mod		0.9361***
Lowl_low		1.0321***
Lowl_stab		1.1126***
Carp_mod		0.3309*
Carp_low		0.5830***
Carp_stab		0.7217***
Number of observation	1284	214
(S)LL constant	-1201.14	
(S)LL model	-1070.78	-951.34

Note: *, **, *** denote significance at 10%, 5%, and 1% level, respectively. SQ_ASC - alternative specific constant for SQ option; SQ_ASC_riskse - interaction effect of SQ and the dummy variable denoting risk seekers (risk seeker =1 if midCRRA<0); Lowl_high - highly threatened Lowland population; Lowl_mod - moderately threatened Lowland population; Lowl_low - low threat level Lowland population; Lowl_stab - stable Lowland population; Carp_mod - moderately threatened Carpathian population; Carp_low - low threatened Carpathian population, and Carp_stab - stable Carpathian population.

The interesting finding with respect to this paper is the statistically significant interaction between the ASC representing the current situation and the dummy indicating whether a respondent belongs, based on the results of the lottery, to the group of risk seekers. In both models, the parameter for this interaction is statistically significant at 5%. Risk seekers have, accordingly, a higher propensity to choose the current situation when asked to make a choice among the presented programs to protect the lynx populations. The current situation is the most risky option in terms of lynx survival. Overall, both models show that respondents would benefit from higher protection levels, but that respondents who belong to the group of risk seekers are more willing to accept the current situation. Table 8 reports the marginal willingness to pay (MWTP) for each protection level for that the parameter estimates is statistically significant in the RPL model.

Table 8. Marginal willingness to pay estimates (in zł).

		RPL	
		MWTP	95%-interval
Lowland	Low threat level	212.53	147.88-277.18
	Stable	188.47	129.82-247.12
Carpathian	Low threat level	76.63	46.49-106.77
	Stable	81.23	49.29-113.17

Note: the confidence intervals are calculated using the Krinsky-Robb procedure with 1000 draws.

We interpret the mean marginal WTP estimates to indicate that respondents are more willing to pay for improving the protection of the Lowland population than for the Carpathian population. This could be because respondents have considered the different baseline conditions for both populations, i.e., the different number of animals in each population. People may not want to give up one of the two populations and, therefore, respond to this situation with a higher WTP for protecting the Lowland population in order to increase the likelihood that this population will survive as well (for further results on this aspect see Bartczak and Meyerhoff, 2012). The overlapping confidence intervals for both the low threat level and the stable protection level suggest that the MWTP estimates are not statistically significantly different. Thus, we cannot argue that people are willing to pay more for a stable population compared to a low threat level lynx population.[4] Table 9 reports the compensating surplus of both the risk seekers and non-risk seekers. It presents the welfare change produced by departing from the status quo (V^0) and implementing a new management scenario (V^1). The measures are computed using the following formula:

$$CS_i = -\frac{1}{\beta_{Cost}}\left(V_i^0 - V_i^1\right) \quad (8)$$

with $-\beta_{Cost}$ assumed to be the constant marginal utility of income. In the present case, V^0 represents a continuation of the current lynx protection policy in Poland, i.e. a reaching a critically threatened level of the Lowland population and a highly threatened level of the Carpathian population in 20 years, and V^1, on the other hand, represents stable lynx populations. In both models, the estimates for risk seekers show a substantially lower compensating surplus than those for non-risk seekers. The complete combinatorial approach suggested by Poe et al. (2005) allows for the rejection of the null-hypothesis of equal willingness to pay figures for both models and both populations. Both risk seekers and non-risk seekers have different preferences for the protection of the lynx populations, i.e. risk preferences revealed in the lottery do significantly affect preferences for lynx protection and thus stated WTP.

[4] Lew et al. (2010) and Jacobsen et al. (2012) found similar results of marginal WTP for wildlife conservation programs. Lew et al. (2010) suggest that this behavior can be explained by higher levels of uncertainty imposed on respondents in the case of large-scale improvement in species protection in combination with the long-term character of such projects (smaller improvements have higher chances to occur during respondents' lifetime). The other reason could be that people "*may only wish to get the species back on track in the near-term, as opposed to "fixing" the whole problem all at once*" (Lew et al., 2010).

Table 9: Risk seekers and non-risk seekers compensating surplus for reaching stable lynx populations in Poland (in zł).

	Risk seeker		Non-risk seeker		
	CS	95%-interval	CS	95%-interval	Poe-test
Lowland -> Stable Carpathian highly threatened (SQ)	107.21	-22.36-201.76	191.18	83.49-336.24	< 0.05
Carpathian -> Stable Lowland critically threatened (SQ)	61.71	-69.34-163.49	145.68	42.08-252.53	< 0.05

Note: the confidence intervals are calculated using the Krinsky-Robb procedure with 1,000 draws.

Figures 2 and 3 show the compensating surplus for all possible combinations of protection levels for both lynx populations. The surface of the graph has been smoothed using the Gnuplot software and the Gaussian kernel technique. The main difference between the two surfaces is the impact on WTP that is due to incorporating the interaction effect when calculating the compensating surplus (CS) measures for the risk seekers. This effect moves the WTP surface for the risk seekers down. For risk seekers and non-risk seekers the highest CS would be realized when conservation policy would bring the two populations to a low threat of extinction. For the risk-seekers this would result in a welfare gain of approximately 120 zł per year but for the non-risk seekers it would result in a higher welfare gain of approximately 230 zł per year.

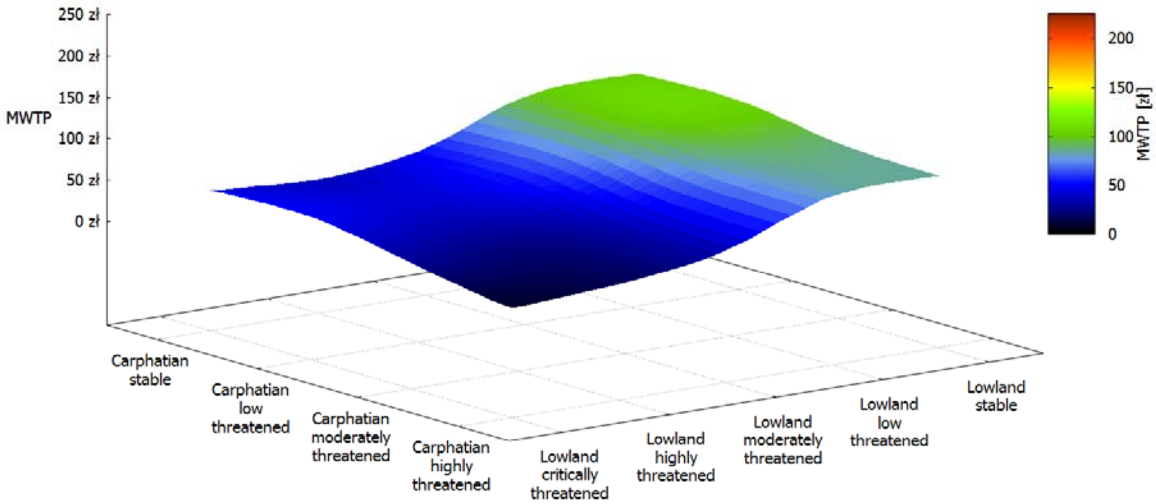

Figure 2. Compensating surplus of risk seekers for protecting both lynx populations.

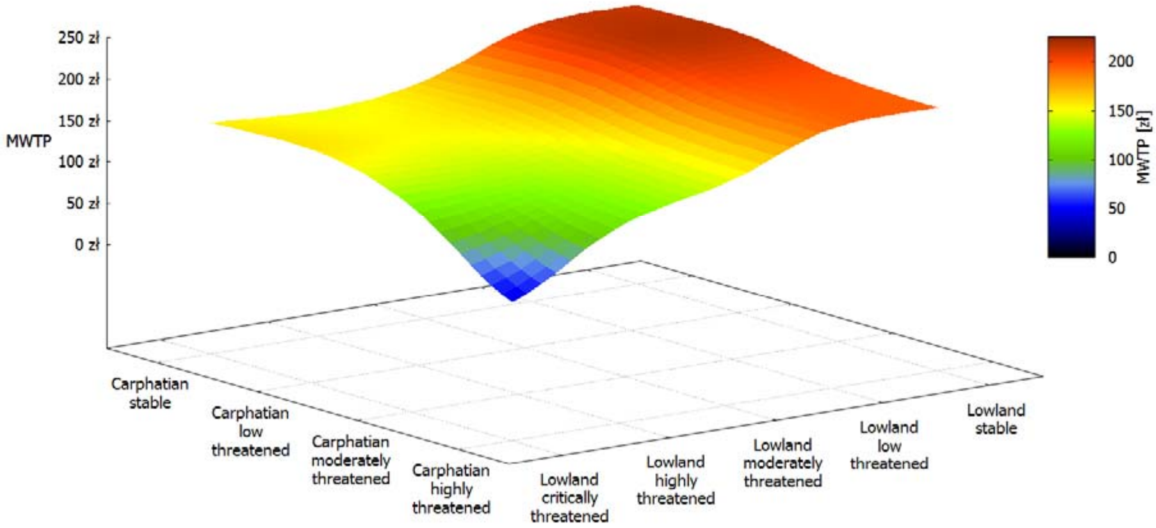

Figure 3. Compensating surplus of non-risk seekers for protecting both lynx populations

5. Conclusions and discussion.

The outcomes of many environmental programs, including species protection programs, are rarely known with certainty. We hypothesised that individual risk preferences, which are known to influence a variety of behaviours, are likely to affect peoples' choices with respect to their WTP for the (uncertain) outcomes of environmental programmes.

In the present paper we investigate this issue using a CE in the context of lynx protection in Poland, combined with a widely-used lottery choice experiment with real payoffs designed to measure individuals risk preferences. Our two main results are: firstly , in general, risk-seeking respondents are more likely to choose the SQ, which is the most risky option in terms of lynx survival; secondly, by eliciting individual risk preferences we have been able to demonstrate that preferences for lynx preservation in Poland are heterogeneous, with risk seekers revealing a substantially lower compensating surplus than that for non-risk seekers.

These results come with the caveat that we have assumed that both the observed environmental and financial decision-making are consistent with expected utility theory and that risk preferences are stable across domains. Considering the first point, this allowed us to use the standard MPL format in which the preference function is an (exogenously) determined probability weighting function and therefore the risk preferences picked up are towards the outcome (money). But it may be the case that, instead risk preferences over financial outcomes are non-EU based and focused on probabilities. Riddel (2012) finds evidence – in both the financial and environmental domains – that risk preferences are characterized by an inverse S-shaped function in which subjects tend to overweight extreme positive outcomes and low probability extreme negative outcomes relative to EU, the latter being more pronounced in the environmental domain. However, she also found that EU was an adequate model for one particular group – risk seekers. This, we might infer that in our study the responses for risk seekers may be relatively robust but for the rest of the sample they may be biased, particularly when transferring across domains.

Turning to this particular issue, we cannot ignore the evidence that exists to suggest risk preferences are not stable across domains (e.g. Dohmen *et al*., 2011; Wakker and Deneffe, 1996), contrary to the standard economic assumption, and may also vary when the risk is social as opposed to private (Weber *et al*., 2002). As noted above, Riddel (2012) found the probability weighting function to be different in magnitude (but not shape) in the financial and environmental domains. Nevertheless, risk attitudes have a significant impact on our models. In interpreting our results we do not claim that individuals are characterized by the same risk preferences towards investment in private goods as towards public goods. The results of the study simply show, that in the context of lynx preservation in Poland, there is a relationship between risk preferences in the financial context and investments in environment.

These two caveats aside, our findings suggest that much more research is needed in relation to how complex risk preferences affect complex environmental choices in stated preference surveys. In respect of the finding that that increasing risk aversion lowers WTP for higher levels of protection it may be that instead of picking up risk preferences towards the environment (as assumed) we have picked up preferences towards spending money on 'implausible' projects.

Regarding the SQ, this paper raises the possibility that choice of the SQ may be linked to fundamental risk preferences, even if exacerbated by psychological influences such as framing or anchoring effects (Tversky and Kahneman, 1974). As such, so-called SQ bias may not be as large in CE's that value programs with uncertain outcomes as it is sometimes reported. Therefore, it may be prudent to elicit individual risk preferences as a possible explanatory variable in order to estimate the impact on estimated WTP and to more reliably predict the degree of SQ bias actually present in the sample. Of course, this observation may only apply in situations like ours where the current situation is more risky i.e. doing nothing is more likely to result in extinction. Different findings might result if the SQ were not much riskier than the hypothetical options e.g. forest conservation where the present situation simply keeps the present mixture of tree species. This question can only be addressed in future empirical work.

We consider this to be a 'first step' in this research agenda rather than the 'final say'. Much is yet to be learned about how risk and environmental preferences interact and impact on WTP for public goods and whether financial lottery choices (which are more familiar and incentivized as opposed to environmental lotteries which are unfamiliar and hypothetical) are in fact a good proxy for environmental risk preferences. If they turned out not to be, then we might ask whether a potential environmental lottery should be constructed instead for the subject of the environmental valuation survey, or should it be applied to another environmental good or service? Adaptations to the MPL approach to account for potential probability weightings (e.g. Tanaka et al., 2010) could also be considered in the future, particularly if it were suspected that the majority of the sample might be risk neutral or risk averse with respect to the environment. Finally, it remains an issue for further research on environmental valuation how risk preferences may interact with other influences such as altruistic preferences and non-use motivations.

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Faculty of Economic Sciences
University of Warsaw
44/50 Długa St.
00-241 Warsaw
www.wne.uw.edu.pl