WILDFIRES IN POLAND: THE IMPACT OF RISK PREFERENCES AND LOSS AVERSION ON ENVIRONMENTAL CHOICES

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Highlights:

- We explore loss aversion in environmental and financial domains
- We examine transferability of risk preferences over finance to environmental domain
- We apply multiple-price list auction to measure individual risk aversion and loss aversion parameters
- We confirming that environmental choices are consistent with Cumulative Prospect Theory

Abstract

This paper examines how risk preferences and loss aversion affect choices over a risky environmental good, wildfire prevention in Poland. We collect data in a stated preference survey that allows us to calculate both risk aversion and loss aversion parameters from individual respondents in both the financial and environmental domains. In doing so, we are able to confirm that their behaviour is consistent with prospect theory and holds for the majority of respondents. Additionally, we find little evidence of domain specificity of risk: responses to the financial risk questions were good predictors of responses to the environmental risk questions.

1. Introduction

One area of non-market valuation that raises fundamental questions both in terms of respondent cognition and subsequent analysis as well as interpretation is the valuation of risky environmental goods. Whilst there is a growing body of evidence with respect to peoples' preferences over risky environmental goods – focussing, for example, on outcome uncertainty (Richardson and Loomis, 2009) or supply uncertainty (Rigby et al., 2011; Rolfe and Windle, 2010; Glenk and Columbo, 2011) – many open questions nevertheless remain. One of the open question is as to whether peoples' choices are driven primarily by risk attitudes to the environment, to finance or to some combination of both but the more pressing question is to identify the most appropriate behavioural model to guide analysis and ultimately improve the predictive powers of our willingness-to-pay (WTP) models.

Standard economic analytical techniques assume Expected Utility Theory (EUT) as the underlying model when estimating WTP. If this assumption is inappropriate for risky environmental decisions, WTP will be underestimated (see Riddell, 2012). A number of psychological studies, in particular Weber et al. (2002), provide strong evidence to the effect that risk preferences are domain specific, but this only goes part of the way in explaining how respondents' choices may be influenced by their fundamental risk preferences.

Against this background, Riddell (2012) provides a framework within which to capture environmental risk preferences in such a way that allows environmental choices to be elicited, interpreted and analysed in exactly the same way as risky financial choices. By eliciting a probability weighting function as well as a risk preference function she was also able to establish that prospect theory is a better descriptor of behaviour than EUT. In this paper, we replicate her analysis in both contexts but extend it to consider the third parameter of prospect theory, namely loss aversion. We apply Tanaka et al. (2010) procedures in the context of financial risks but then adapt them to provide, for the first time, evidence in respect of environmental loss aversion, in our case in the context of wildfire risk reduction in Poland.

Specifically, by capturing both risk aversion and loss aversion parameters from individual respondents we are able to examine the value function in its entirety. We confirm that behaviour is consistent with prospect theory in both the cases of environmental gains and environmental losses. We also provide additional evidence on the transferability of risk preferences over finance to other domains, in this case finding no strong evidence of domain specificity.

The remainder of the paper is as follows. Section 2 details the theoretical specifications and empirical methods used to define and elicit the relevant parameters. Section 3 gives brief details of the survey and sample characteristics whilst Section 4 contains the results of our analysis. Section 5 discusses these results and offers some observations on their implications for future stated preference survey design.

2. Theoretical considerations

We consider Prospect Theory (PT) (Kahneman and Tversky, 1979) as an alternative to EUT in the domains of gains and losses. In PT risk aversion, loss aversion and nonlinear probability weighting jointly shape the utility function. Following Tanaka et al. (2010) we assume the one-parameter form of Prelec's (1998) axiomatically derived weighting function. Moreover, assuming a piece-wise power function for $v(x)$, the value function can be written:

$$v(x) = \begin{cases} x^{1-\sigma} \; if \; x \geq 0 \\ -\lambda(-x)^{1-\sigma} \; if \; x < 0 \end{cases} \tag{1}$$

where x is an outcome, σ represents concavity of the value function and λ is the degree of loss aversion. If an individual is risk loving then σ<0, if she is risk neutral then σ=0, and risk averse if σ>0.

The loss aversion parameter λ measures one's sensitivity to loss compared to gain. In PT, gains and losses are compared to a reference point (the current position) and can accommodate different weightings - specifically that losses are weighted more heavily than equivalent gains. A probability weighting function considered in the current study is[1]:

$$\pi(p) = \frac{1}{\exp\left[\ln\left(\frac{1}{p}\right)\right]^{\alpha}} \tag{2}$$

where p is the probability of the outcome x and α is the probability sensitivity parameter.

If α<1, the weighting function is inverted S-shaped, i.e. individuals overweight small probabilities and underweight large probabilities (Tversky and Kahneman, 1992) and hence are probabilistic risk averse for low likelihood losses and high likelihood gains and, conversely, probabilistic risk seeking for low likelihood gains and high likelihood

[1] This process of transforming the probabilities into decision weights breaks the independence axiom i.e. probabilities and outcomes are independent (Starmer, 2000).

losses. If α>1 then the weighting function is S-shaped. In both of these cases, preferences are non-linear.

By contrast, if preferences are linear and probability weighting is absent, the probability sensitivity parameter α equals 1, as the loss aversion parameter (i.e. λ=1) and EUT applies.[2]

The PT utility function for a two outcome gamble can be written as:

$$U(x,p;y,q) = \begin{cases} \pi(p)v(x) + \left(1-\pi(p)\right)v(y) & if\ x > y > 0\ or\ x < y < 0 \\ \pi(p)v(x) + \pi(q)v(y) & if\ x < 0 < y \end{cases} \qquad (3)$$

where: x and y are the outcomes, and p and q are probabilities associated with those outcomes.

Table 1. Values of EUT and PT parameters.

Function	Parameters	Theory			
		Expected Utility*		Prospect	
Weighting function	Probability sensitivity parameter	α =1	Probability weighting is absent	α <1	Overweighting small probabilities & underweight large probabilities
Value function	Loss aversion parameter	λ =1	Losses are weighted the same as gains	λ > 1	Losses are weighed more heavily than gains

Note: * Assuming a standard EU functional form.

[2] In EUT the utility function is linear in p i.e. $EU(x;p) = \sum_i p_i \ v(x_i)$.

3. Method

Individual willingness to take risk cannot be measured straightforwardly and because of that, in the past decades a wide set of instruments has been developed to elicit risk attitudes (see e.g. Weber and Johnson, 2008). Two main approaches for risk elicitation can be distinguished. The first one allows the researcher to infer risk preferences based on individuals actual choices in real or hypothetical games (e.g. Binswanger 1980, Holt and Laury, 2002 or Tanaka, 2010). A major advantage of this approach is that it allows risk preferences to be ranked and identifies groups of risk seeking, risk loving and risk-neutral people. The second approach elicits risk attitudes by asking individuals about their engagement in their daily life risky situations (e.g. Jackson et al., 1972 or Weber et al, 2002).

In this section, we first outline Tanaka et al.'s (2010) experimental lotteries design which we adapted for the purpose of our study. The advantage of this design is that it allows us to estimate empirical specifications that nest both EUT and PT. Based on the experimental results it is possible to determine whether EUT or PT better fits the data. Tanaka et al.'s (2010) extended multiple price list (MPL) approach has been tested *inter alia* by Riddel (2012) and Liu (2013). In the second part of this section, we describe an alternative risk attitude elicitation device – Domain Specific Risk Talking scale (DOSPERT) developed by Weber et al. (2002). The DOSPERT domains scores have been shown to be associated with real-life risk taking activities *inter alia* by Hanoch et al. (2006). Applying the two approaches allows for psychological validation of financial and environmental risk measures and the derived parameters.

3.1 Elicitation of probability weighting and loss aversion parameters

To capture risk preferences in the financial and environmental domains we apply Tanaka et al.'s (2010) MPL design. Following this approach, individuals are presented with three series of lottery pairs and asked to choose one lottery for each pair. When moving down the list of lotteries, payoffs in Option B increase while everything else is fixed. The lotteries are designed in a way that any combination of choices in the three series determines a particular interval of prospect theory parameter values (see Table 2).[3]

[3] The standard MPL approach assumes underlying EUT behavior in the lottery choices (see e.g. Binswanger, 1980 or Holt and Laury, 2002).

Table 2. Three series of pairwise lottery choices for the financial outcome domain.

Series 1								
Option A				Option B				EV(A)-EV(B)
Prob.	Payoff	Prob.	Payoff	Prob.	Payoff	Prob.	Payoff	
0.3	400 zł	0.7	100 zł	0.1	680 zł	0.9	50 zł	77 zł
0.3	400 zł	0.7	100 zł	0.1	750 zł	0.9	50 zł	70 zł
0.3	400 zł	0.7	100 zł	0.1	830 zł	0.9	50 zł	62 zł
0.3	400 zł	0.7	100 zł	0.1	930 zł	0.9	50 zł	52 zł
0.3	400 zł	0.7	100 zł	0.1	1 060 zł	0.9	50 zł	39 zł
0.3	400 zł	0.7	100 zł	0.1	1 250 zł	0.9	50 zł	20 zł
0.3	400 zł	0.7	100 zł	0.1	1 500 zł	0.9	50 zł	-5 zł
0.3	400 zł	0.7	100 zł	0.1	1 850 zł	0.9	50 zł	-40 zł
0.3	400 zł	0.7	100 zł	0.1	2 200 zł	0.9	50 zł	-75 zł
0.3	400 zł	0.7	100 zł	0.1	3 000 zł	0.9	50 zł	-155 zł
0.3	400 zł	0.7	100 zł	0.1	4 000 zł	0.9	50 zł	-255 zł
0.3	400 zł	0.7	100 zł	0.1	6 000 zł	0.9	50 zł	-455 zł
0.3	400 zł	0.7	100 zł	0.1	10 000 zł	0.9	50 zł	-855 zł
0.3	400 zł	0.7	100 zł	0.1	17 000 zł	0.9	50 zł	-1 555 zł
Series 2								
Option A				Option B				EV(A)-EV(B)
Prob.	Payoff	Prob.	Payoff	Prob.	Payoff	Prob.	Payoff	
0.9	400 zł	0.1	300 zł	0.7	540 zł	0.3	50 zł	-3 zł
0.9	400 zł	0.1	300 zł	0.7	560 zł	0.3	50 zł	-17 zł
0.9	400 zł	0.1	300 zł	0.7	580 zł	0.3	50 zł	-31 zł
0.9	400 zł	0.1	300 zł	0.7	600 zł	0.3	50 zł	-45 zł
0.9	400 zł	0.1	300 zł	0.7	620 zł	0.3	50 zł	-59 zł
0.9	400 zł	0.1	300 zł	0.7	650 zł	0.3	50 zł	-80 zł
0.9	400 zł	0.1	300 zł	0.7	680 zł	0.3	50 zł	-101 zł
0.9	400 zł	0.1	300 zł	0.7	720 zł	0.3	50 zł	-129 zł
0.9	400 zł	0.1	300 zł	0.7	770 zł	0.3	50 zł	-164 zł
0.9	400 zł	0.1	300 zł	0.7	830 zł	0.3	50 zł	-206 zł
0.9	400 zł	0.1	300 zł	0.7	900 zł	0.3	50 zł	-255 zł
0.9	400 zł	0.1	300 zł	0.7	1 000 zł	0.3	50 zł	-325 zł
0.9	400 zł	0.1	300 zł	0.7	1 100 zł	0.3	50 zł	-395 zł
0.9	400 zł	0.1	300 zł	0.7	1 300 zł	0.3	50 zł	-535 zł
Series 3								
Option A				Option B				EV(A)-EV(B)
Prob.	Payoffs	Prob.	Payoffs	Prob.	Payoffs	Prob.	Payoffs	
0.5	250 zł	0.5	-40 zł	0.5	300 zł	0.5	-210 zł	60 zł
0.5	40 zł	0.5	-40 zł	0.5	300 zł	0.5	-210 zł	-45 zł
0.5	10 zł	0.5	-40 zł	0.5	300 zł	0.5	-210 zł	-60 zł
0.5	10 zł	0.5	-40 zł	0.5	300 zł	0.5	-160 zł	-85 zł
0.5	10 zł	0.5	-80 zł	0.5	300 zł	0.5	-160 zł	-105 zł
0.5	10 zł	0.5	-80 zł	0.5	300 zł	0.5	-140 zł	-115 zł
0.5	10 zł	0.5	-80 zł	0.5	300 zł	0.5	-110 zł	-130 zł

The switching points in Series 1 and 2 jointly determine the parameter for the curvature of the value function (σ) and the probability weighting parameter (α). In Series 1, when an individual switches from Option A at row N it means that she prefers Option A over Option B at N-1 rows and prefers Option B over Option A at row N (and following rows)[4]. The same approach is used in Series 2 (rows notation K-1 and K). To determine ranges for both parameters the following inequalities should be satisfied:

$$
\begin{cases}
\begin{gathered}
\left(x_{S1,A,N-1}\right)^{\sigma} exp[-(-\,ln\left(p_{S1,N-1}\right))^{\alpha}] + \left(y_{B,N-1}\right)^{\sigma}\{1 - exp[-(-\,ln\left(p_{S1,N-1}\right))^{\alpha}]\} > \\
\left(x_{S1,B,N-1}\right)^{\sigma} exp[-(-\,ln\left(q_{S1,N-1}\right))^{\alpha} + \left(y_{S1,A,N-1}\right)^{\sigma}\{1 - exp[-(-\,ln\left(q_{S1,N-1}\right))^{\alpha}]\}
\end{gathered} \\
\begin{gathered}
\left(x_{S1,B,N}\right)^{\sigma} exp[-(-\,ln\left(p_{S1,N}\right))^{\alpha}] + \left(y_{A,N}\right)^{\sigma}\{1 - exp[-(-\,ln\left(p_{S1,N}\right))^{\alpha}]\} > \\
\left(x_{S1,A,N}\right)^{\sigma} exp[-(-\,ln\left(q_{S1,N}\right))^{\alpha} + \left(y_{S1,B,N}\right)^{\sigma}\{1 - exp[-(-\,ln\left(q_{S1,N}\right))^{\alpha}]\}
\end{gathered} \\
\begin{gathered}
\left(x_{S2,A,K-1}\right)^{\sigma} exp[-(-\,ln\left(p_{S2,K-1}\right))^{\alpha}] + \left(y_{B,K-1}\right)^{\sigma}\{1 - exp[-(-\,ln\left(p_{S2,K-1}\right))^{\alpha}]\} > \\
\left(x_{S2,B,K-1}\right)^{\sigma} exp[-(-\,ln\left(q_{S2,K-1}\right))^{\alpha} + \left(y_{S2,A,K-1}\right)^{\sigma}\{1 - exp[-(-\,ln\left(q_{S2,K-1}\right))^{\alpha}]\}
\end{gathered} \\
\begin{gathered}
\left(x_{S2,B,K}\right)^{\sigma} exp[-(-\,ln\left(p_{S2,K}\right))^{\alpha}] + \left(y_{A,K}\right)^{\sigma}\{1 - exp[-(-\,ln\left(p_{S2,K}\right))^{\alpha}]\} > \\
\left(x_{S2,A,K}\right)^{\sigma} exp[-(-\,ln\left(q_{S2,K}\right))^{\alpha} + \left(y_{S2,B,K}\right)^{\sigma}\{1 - exp[-(-\,ln\left(q_{S2,K}\right))^{\alpha}]\}
\end{gathered}
\end{cases}
\qquad (4)
$$

where x and y are outcomes, *p* is the probability of the outcome x, N and K denote the number of rows, A and B indicate the lottery options, and S1 and S2 denote Series 1 and Series 2, respectively. The pair of parameters α and σ is not uniquely determinable. In this case we follow Tanaka et al. (2010) and their convention approximating α and σ by taking the midpoint of the interval.

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[4] Similarly to Tanaka et al. (2010) we tried to enforce monotonic switching by asking respondents at which row they would switch from Option A to Option B in each series, noting that they can also start to choose Option B with the first row. However, those who insisted on switching back were allowed to do so.

The loss aversion parameter can be determined by the switching points in Series 3 after obtaining an estimate of σ based on choices in Series 1 and Series 2. Similar to α and σ, the loss aversion parameter λ can also be estimated as the midpoint of an interval; a higher λ represents a higher degree of loss aversion.

Following Riddel (2012), to capture risk preferences not only in the financial domain but also in the environmental domain, we established a set of corresponding hypothetical lotteries whose outcomes were reductions in the risk of forest wildfires in Poland. In addition to the lottery choices, which are comparable to Riddel's survey, we also applied a third set of lotteries (Series 3) to explore individuals' loss aversion. This way, we frame our analysis in both the gain and loss domains.

In the environmental lottery tasks in Series 1 and Series 2, respondents were asked to make a choice between programs that, instead of financial rewards, presented them environmental effects of programs to reduce the risk of forest wildfires. They were told that two potential programs to further reduce the risk of forest fires are available in addition to the current fire protection management. However, the success rate of the two options is different. The results were described as the annual average reduction of burned forest area in Poland and were presented as uncertain (as they might depend on various factor earlier explained to the respondents). The respondents were asked to assume the costs of these programs were the same. Table 3 shows all the environmental choices presented to respondents.

Table 3. Three series of pairwise lottery choices for the environmental outcome domain

				Series 1				
Program A				Program B				EV(A)-EV(B)
Prob.	Saved forest	Prob.	Saved forest	Prob.	Saved forest	Prob.	Saved forest	
0,3	100 ha	0,7	25 ha	0,1	170,0 ha	0,9	12,5 ha	19,3 ha
0,3	100 ha	0,7	25 ha	0,1	187,5 ha	0,9	12,5 ha	17,5 ha
0,3	100 ha	0,7	25 ha	0,1	207,5 ha	0,9	12,5 ha	15,5 ha
0,3	100 ha	0,7	25 ha	0,1	232,5 ha	0,9	12,5 ha	13,0 ha
0,3	100 ha	0,7	25 ha	0,1	265,0 ha	0,9	12,5 ha	9,8 ha
0,3	100 ha	0,7	25 ha	0,1	312,5 ha	0,9	12,5 ha	5,0 ha
0,3	100 ha	0,7	25 ha	0,1	375,0 ha	0,9	12,5 ha	-1,3 ha
0,3	100 ha	0,7	25 ha	0,1	462,5 ha	0,9	12,5 ha	-10,0 ha
0,3	100 ha	0,7	25 ha	0,1	550,0 ha	0,9	12,5 ha	-18,8 ha
0,3	100 ha	0,7	25 ha	0,1	750,0 ha	0,9	12,5 ha	-38,8 ha
0,3	100 ha	0,7	25 ha	0,1	1 000,0 ha	0,9	12,5 ha	-63,8 ha
0,3	100 ha	0,7	25 ha	0,1	1 500,0 ha	0,9	12,5 ha	-113,8 ha
0,3	100 ha	0,7	25 ha	0,1	2 500,0 ha	0,9	12,5 ha	-213,8 ha
0,3	100 ha	0,7	25 ha	0,1	4 250,0 ha	0,9	12,5 ha	-388,8 ha
				Series 2				
Program A				Program B				EV(A)-EV(B)
Prob.	Saved forest	Prob.	Saved forest	Prob.	Saved forest	Prob.	Saved forest	
0,9	100 ha	0,1	75 ha	0,7	135,0 ha	0,3	12,5 ha	-0,8 ha
0,9	100 ha	0,1	75 ha	0,7	140,0 ha	0,3	12,5 ha	-4,3 ha
0,9	100 ha	0,1	75 ha	0,7	145,0 ha	0,3	12,5 ha	-7,8 ha
0,9	100 ha	0,1	75 ha	0,7	150,0 ha	0,3	12,5 ha	-11,3 ha
0,9	100 ha	0,1	75 ha	0,7	155,0 ha	0,3	12,5 ha	-14,8 ha
0,9	100 ha	0,1	75 ha	0,7	162,5 ha	0,3	12,5 ha	-20,0 ha
0,9	100 ha	0,1	75 ha	0,7	170,0 ha	0,3	12,5 ha	-25,3 ha
0,9	100 ha	0,1	75 ha	0,7	180,0 ha	0,3	12,5 ha	-32,3 ha
0,9	100 ha	0,1	75 ha	0,7	192,5 ha	0,3	12,5 ha	-41,0 ha
0,9	100 ha	0,1	75 ha	0,7	207,5 ha	0,3	12,5 ha	-51,5 ha
0,9	100 ha	0,1	75 ha	0,7	225,0 ha	0,3	12,5 ha	-63,8 ha
0,9	100 ha	0,1	75 ha	0,7	250,0 ha	0,3	12,5 ha	-81,3 ha
0,9	100 ha	0,1	75 ha	0,7	275,0 ha	0,3	12,5 ha	-98,8 ha
0,9	100 ha	0,1	75 ha	0,7	325,0 ha	0,3	12,5 ha	-133,8 ha
				Series 3				
Program A				Program B				EV(A)-EV(B)
Prob.	Saved forest	Prob.	Burned forest	Prob.	Saved forest	Prob.	Burned forest	
0,5	62,5 ha	0,5	10 ha	0,5	75 ha	0,5	52,5 ha	15,0 ha
0,5	10,0 ha	0,5	10 ha	0,5	75 ha	0,5	52,5 ha	-11,3 ha
0,5	2,5 ha	0,5	10 ha	0,5	75 ha	0,5	52,5 ha	-15,0 ha
0,5	2,5 ha	0,5	10 ha	0,5	75 ha	0,5	40,0 ha	-21,3 ha
0,5	2,5 ha	0,5	20 ha	0,5	75 ha	0,5	40,0 ha	-26,3 ha
0,5	2,5 ha	0,5	20 ha	0,5	75 ha	0,5	35,0 ha	-28,8 ha
0,5	2,5 ha	0,5	20 ha	0,5	75 ha	0,5	27,5 ha	-32,5 ha

In series 3, respondents were told that each program, when completed, could end in either success or failure. In the latter case, more forests will be burned than would be the case under the current management regime.[5] Payoffs from the environmental lotteries in Series 3 were presented therefore as either the additional forest area saved from burning or as an increase in the area of forest burned relative to the current area damaged by wildfires. Similar to Riddel (2012), respondents' choices were not incentivized in either domain to allow full comparability, i.e. choices in both domains were hypothetical.

3.2 Risk taking propensity measure

We adopted the 30-item version of the DOSPERT scale from Blais and Weber (2006) (see Table 4). This is a psychometric scale that assesses risk taking in five content domains: financial, health/safety, recreational, ethical, and social. In this approach, respondents are asked to rate the likelihood of engagement in domain-specific risky activities using a 7-point rating scale ranging from 1 – "extremely unlikely" to 7 – "extremely likely". Then the activity-specific risk-taking propensity scores are aggregated into domain-specific risk-taking propensity scores.

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[5] At the beginning of the survey the risk of forest wildfires in Poland, their effects, risk factors and the possible methods to reduce this risk were described to respondents based on historical data.

Table 4. Domain-Specific Risk-Taking (DOSPERT) items.

Financial	***Health/safety***
1. Betting a day's income at the horse races. 2. Investing 10% of your annual income in a moderate growth mutual fund. 3. Betting a day's income at a high-stake poker game. 4. Investing 5% of your annual income in a very speculative stock. 5. Betting a day's income on the outcome of a sporting event 6. Investing 10% of your annual income in a new business venture.	1. Drinking heavily at a social function. 2. Engaging in unprotected sex. 3. Driving a car without wearing a seat belt. 4. Riding a motorcycle without a helmet. 5. Sunbathing without sunscreen. 6. Walking home alone at night in an unsafe area of town.
Recreational	***Ethical***
1. Going camping in the wilderness. 2. Going down a ski run that is beyond your ability. 3. Going whitewater rafting at high water in the spring. 4. Taking a skydiving class. 5. Bungee jumping off a tall bridge. 6. Piloting a small plane.	1. Taking some questionable deductions on your income tax return. 2. Having an affair with a married man/woman. 3. Passing off somebody else's work as your own. 4. Revealing a friend's secret to someone else. 5. Leaving your young children alone at home while running an errand. 6. Not returning a wallet you found that contains 1000 zł.
Social	
1. Admitting that your tastes are different from those of a friend. 2. Disagreeing with an authority figure on a major issue. 3. Choosing a career that you truly enjoy over a more secure one. 4. Speaking your mind about an unpopular issue in a meeting at work. 5. Moving to a city far away from your extended family. 6. Starting a new career in your mid-thirties.	

Note: responses were recorded on a 7-point rating scale ranging from 1 – "extremely unlikely" to 7 – "extremely likely".

4. The Survey

Interviews were conducted face-to-face with members of the public by a professional polling agency in five cities in Poland in August and September 2013.[6] A quota sampling was applied representative of the Polish population in terms of age and

[6] Gdańsk, Łódź, Katowice, Poznań, and Warsaw.

gender. In total, 630 interviews were conducted. All respondents participated both in financial and in environmental experiments.[7] Among them, 34 made multiple switches in the lottery tasks and were therefore excluded from any further analysis. Table 5 reports basic socio-demographics and the responses to a question asking respondents how important they think it is to manage the risk of wildfires in Poland.

Table 5. Descriptive statistics of the sample and their attitudes toward forest fires.

	Share	Mean	St. dev.	Median
Women	56%			
Age		39	12	37
Education				
- Primary	1%			
- Secondary	58%			
- High	41%			
Net monthly individual income in zł		2365	1726	2500
Wildfires in Poland are a				
- *definitely important issue*	48%			
- *rather important issue*	42%			
- *neither/nor*	8%			
- *rather unimportant issue*	2%			
- *definitely unimportant issue*	0%			

Note: Number of respondents, N=596. Nominal exchange rate 1€ = 4.12zł

5. Results

5.1 Lottery choices – values of parameters

If both the probability sensitivity parameter α=1 and the loss aversion parameter λ=1, then the assumed value function would reduce to the standard EU function.

[7] Due to limited space we focus on the results and do not describe the survey in detail here. The survey is available on request from the communicating author.

Responses to both Series 1 and 2 jointly determine α. Figure 1 shows the distribution of the switching points for the two first series of financial lotteries. Next, Figure 2 gives the corresponding distribution for the environmental lotteries.

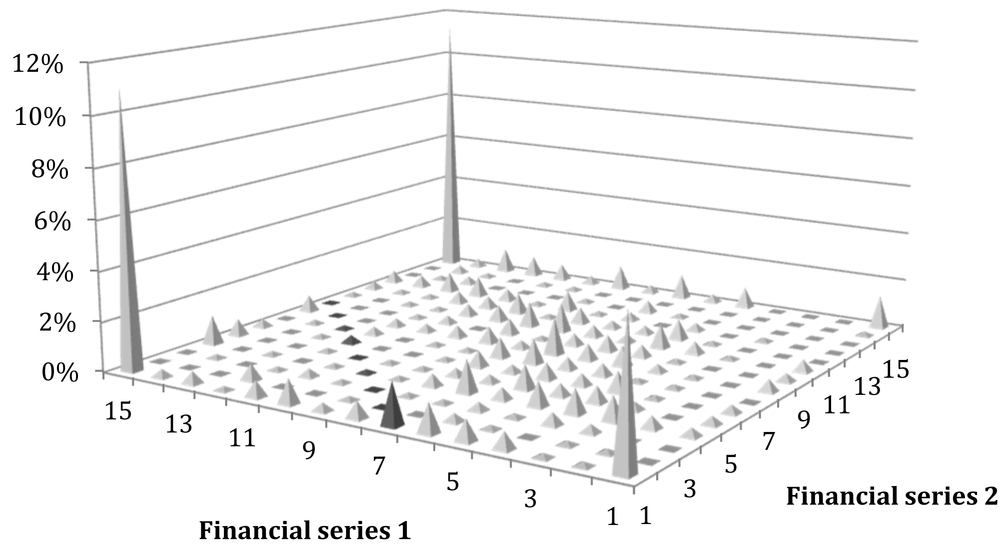


Figure 1. Switching points for financial choices in Series 1 and 2

Note: Black represent the choices consistent with EUT assuming constant relative risk aversion with utility function $u(x) = x^{1-\sigma}/1-\sigma$, i.e. switching points combinations for Series 1 and Series 2: (7, 1), (8, 2), (9, 3), (10, 4), (11, 5), (12, 6), (13, 7), (14,8) and (15-never switch, 9).

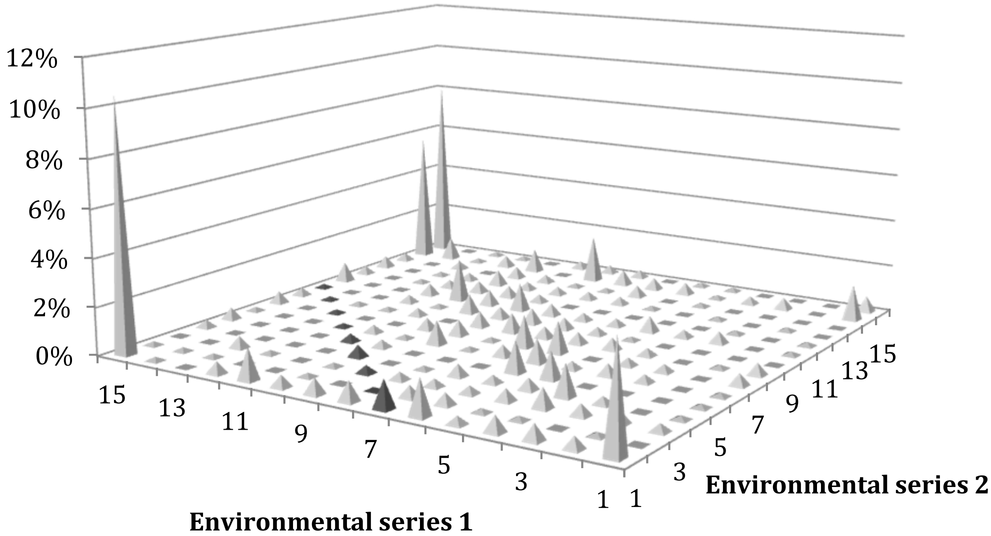


Figure 2. Switching points for environmental choices in Series 1 and 2

Note: Black represents choices consistent with EUT.

In both cases there was no obvious tendency for respondents to cluster around the middle choice of the lotteries series. Results from the financial lotteries suggest that only 2% of respondents made choices consistent with EUT. In the case of the environmental lotteries this share equaled 3%.

T-test reject both the null hypotheses α_F =1 and α_F =1 at the 1% level. The average derived value of the probability weighting parameter α is lower than 1, rejecting EUT in favor of inverted-S shaped probability weighting in both financial and environmental domains. Table 6 presents the statistics for α. Similar results were obtained by Riddel (2012). However, in her study, the probability weighting parameter for the environmental risk was lower than that for financial risk. In our study, based on results from a paired t-test fails to reject the null hypothesis $\bar{\propto}_E = \bar{\propto}_F$ (p-value=0.86). [8] The

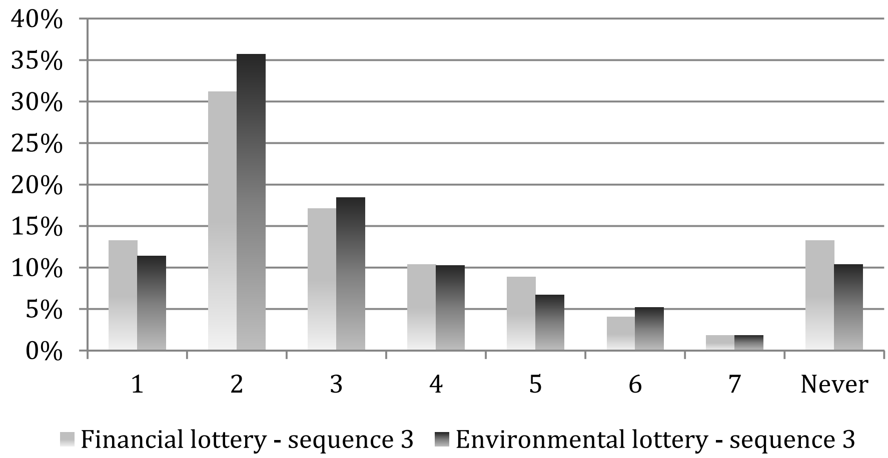
[8] Subscripts E and F denote the environmental domain and the financial domain, respectively.

results of the equality of means test suggest that the probability weighting functions in both environmental and financial domains are similar, meaning that respondents weighed the likelihood of extreme outcomes equally across the two domains[9].

Table 6. Probability sensitivity parameters in Prelec's weighting function (α) in the environmental and the financial domain.

	Mean	Std. Dev.	Minimum	Maximum
α_F	0.770	0.329	0.05	1.45
α_E	0.773	0.324	0.05	1.45

The loss aversion parameter λ is determined by the switching point in Series 3 and by value of parameter σ (the curvature of the value function) obtained from individuals' choices in Series 1 and Series. Figure 3 shows the distribution of switching points for Series 3 of the financial and environmental lotteries.



[9] The results of Mann-Whitney test suggest that there is not a statistically significant difference between the underlying distributions of the probability weighting parameter in the financial and environmental domains (z = 1.201, p-value = 0.22).

Figure 3. Distribution of switch-points between Lottery A to B

The share of individuals with λ in the interval 0.9-1.1 (consistent with the EUT) in the financial and the environmental lotteries was equal to 4% and 5%, respectively. The average estimated value of the loss aversion parameter in the financial series of lotteries was 3.010, whereas for the environmental series this value was 3.019.[10] The results of a paired t-test with the null hypothesis $\bar{\lambda}_E = \bar{\lambda}_F$ fails to reject the null (p-value=0.29) suggesting that both values are not statistically significant different from each other.[11] However, in both cases, the average estimated value of loss aversion is significantly different from 1 indicating choices are not consistent with EUT. Using t-test we can reject both the null hypotheses $\lambda_F = 1$ and $\lambda_E = 1$ at the 1% level.

Table 7. Loss aversion parameter (λ) in environmental and financial domain.

	Mean	Std. Dev.	Minimum	Maximum
λ_F	3.010	3.934	0.116	13.394
λ_E	3.019	3.916	0.116	13.394

5.2. Risk taking attitudes

Table 8 reports the mean DOSPERT scores. The mean risk-taking level varied between domains with the largest mean in the social area (26.66) and the smallest mean in the ethical domain (11.94). The internal consistency estimates for the risk-taking

[10] Following Liu (2013) we assigned the maximum value of λ at 15 instead of infinity.

[11] The results of Mann-Whitney test confirm that there is not a statistically significant difference between the underlying distributions of the loss aversion parameter in the financial and environmental domains (z-value = -0.094, p-value = 0.92)

scores (i.e. Cronbach's alpha) range from 0.60 to 0.83. Blais and Weber (2006) also found on the groups of the French and British respondents that they were the most adventurous in the social domain and the least in the ethical domain.

Table 8. Domain-Specific Risk-Taking (DOSPERT) Scale.

DOSPERT score – risk taking	Mean	Std. Dev.	Minimum	Maximum	Cronbach's alpha
1. Ethical	11.94	5.02	6	36	0.60
2. Financial	13.64	7.40	6	42	0.83
3. Health/Safety	17.36	6.71	6	38	0.64
4. Recreational	16.80	8.80	6	42	0.83
5. Social	26.66	7.18	6	42	0.71

Based on the responses to the DOSPERT items we calculated five DOSPERT-indices, one for each domain. They are used in the next section to investigate whether the likelihood of engaging in risky activities relates to different domains affects PT parameters obtained from the financial and environmental lottery choice tasks.

5.3. Drivers of domain specificity for probability weighting and loss aversion

As reported, the mean of the probability weighting parameter (α) and the mean of the loss aversion parameter (λ) for both financial and environmental risks are not significantly different. However, there may still be inherent domain-specific preferences caused by other types of heterogeneity within the population. To investigate this we run regression models specifying the probability weighting parameter and the loss aversion parameter as functions of financial (F) and environmental (E) risk preferences. Table 9 reports the results from each time tow models, the first comprising the socio-demographics age, gender, education and income, the second adding five DOSPERT subdomain risk-taking indices (Table 8).

Both times we apply the censored logistic model and assume for the underlying statistical model that it is linear in the coefficients. In case of the probability weighting parameter (α) we censor outside the range 0.05-1.45 (the lowest and the highest value of α) and in case of the loss aversion parameter (λ) we censor outside the range 0.11-15.00.

Starting with the probability weighting parameter (α), we find that three out of the four socio-demographics statistically significantly influence this parameter and help to explain heterogeneity among respondents (Model I). However, the coefficients are very similar and we therefore cannot conclude that they are domain specific. The coefficients for age, gender, and income are positively associated with α, indicating that older persons, females and persons with higher incomes have a less pronounced curvature in their probability weighting function. In contrast, having a higher education does not help to explain heterogeneity among respondents with respect to respondents' probability weighting.

Adding the DOSPERT subscales (Model II) reveals that age and gender still have a positive effect on α although the coefficients are slightly smaller. Income is in Model II only in the environmental domain positively significant. Among the five specific indices three are statistically significant. Respondents who indicated that they are more likely to engage in more risky behaviours in the health and the social domain have a higher value for α, i.e. they have a less pronounced curvature and are thus more likely to not overweight small probabilities. Contrary, respondents who reveal more risky behaviour in the financial domain tend to overweight small probabilities and underweight large probabilities.

Next, moving to the individual loss aversion parameter we find (Model III) that age and income do have a statistically positive influence on loss aversion. Older respondents and respondents with higher incomes are more likely to be more loss averse. The other two socio-demographics do not help to explain heterogeneity among respondents. When we add the DOSPERT subscales to this model (Model IV) the effect of age remains very much the same but income is no longer statistically significant. Among the subscales only the risk attitudes revealed with respect to behaviours in the financial sector are statistically significant. Here, respondents who are willing to take higher risks are less loss averse. All other subscales do not explain heterogeneity among respondents.

Overall, the independent variables used in the four models indicate validity of both measures, the probability weighting parameter (α) and the loss aversion parameter (λ). Older people tend to have a less pronounced curvature with respect to α. An explanation could be that they are more experienced than younger people and thus are less prone to overweight small probabilities. Also older people seem to be more loss averse indicating that they want keep what they have achieved. This seems to be rational as older people have on average fewer opportunities to compensate for losses. The other variable that shows the same influence on both measures is the risk attitude stated towards financial activities. Respondents who are willing to take higher financial risks are more likely to overestimate small probabilities and are at the same time more likely to be less risk averse. Both associations seem to be reasonable as people willing to take higher risks in the financial sector sooner hope to make a profit and less averse against losses that accompany higher risks. However, one has to keep in mind that linking the DOSPERT scale to the probability weighting parameter (α) and the loss aversion parameter (λ) was done in an explanatory manner. Thus, the subscales help to explain heterogeneity and indicate to some extent validity of both parameters α and λ but are not strong validations.

Table 9. Drivers of probability weights (α) individual loss aversion (λ)

	Probability weights (α)				Loss aversion (λ)			
	Model I		Model II		Model III		Model IV	
Parameter	Coeff.	|z-val|	Coeff	|z-val|	Coeff	|z-val|	Coeff	|z-val|
Age*F	**0.0133**	**17.28**	**0.0068**	**7.52**	**0.0397**	**6.53**	**0.0394**	**4.71**
Age*E	**0.0129**	**17.27**	**0.0062**	**6.78**	**0.0401**	**6.58**	**0.0398**	**4.75**
Gender*F	**0.1056**	**3.43**	**0.0852**	**3.01**	0.0587	0.24	0.1141	0.45
Gender*E	**0.1069**	**3.47**	**0.0801**	**2.84**	0.0526	0.21	0.1112	0.44
Higher edu*F	0.0016	0.05	-0.0143	0.50	0.3618	1.43	0.3787	1.49
Higher edu*E	0.0102	0.32	-0.0068	0.23	0.3486	1.38	0.3657	1.43
Income*F (in 1000zł)	**0.0245**	**5.02**	0.0054	1.22	**0.0734**	**1.94**	0.0721	1.76
Income*E (in 1000zł)	**0.0290**	**6.44**	**0.0100**	**2.10**	**0.0727**	**1.92**	0.0712	1.73
DOS_eth.*F			**0.0937**	**4.73**			-0.0401	0.24
DOS_eth.*E			**0.0659**	**3.39**			-0.0491	0.29
DOS_fin.*F			**-0.0403**	**2.68**			**-0.3028**	**2.25**
DOS_fin.*E			**-0.0451**	**3.01**			**-0.2926**	**2.18**
DOS_health.*F			-0.0024	0.14			0.2817	1.91
DOS_health*E			0.0221	1.32			0.2828	1.92
DOS_rec.*F			0.0210	1.58			0.1785	1.54
DOS_rec.*E			0.0069	0.51			0.1779	1.54
DOS_social*F			**0.0548**	**4.71**			-0.1184	1.13
DOS_social.*E			**0.0667**	**5.69**			-0.1210	1.15
Scale	0.3910	40.06	0.3485	39.69	3.3097	36.57	3.2871	36.53
AIC	1074.27		848.75		6138.02		6138.19	
BIC	1119.59		944.42		6183.34		6233.86	
Log likelihood	-528.13		-405.37		-3060.01		-3050.10	
Observations	1136							

6. Discussion and Conclusions

Recent studies as the one by Riddle (2012) show that the assumption that EU models characterise preferences over stochastic environmental gains well is in many cases not justified. In contrast, subjects seem to place more emphasis on low probability environmental gains than one would find under EUT. The fact that probability weighting has been found to be an important component of environmental preference functions suggests that the assumption that environmental preferences can be modelled using EUT or subjective EUT (see for example, Riddel and Shaw (2006), Cameron (2005) or Alberini et al. (2007)) should be modified, particularly when estimating willingness to pay (WTP) for environmental-risk reductions.

The present study has extended this analysis to account for the potential influence of loss aversion. We find that it also significantly impacts preferences. Our results show that most respondents exhibited significant probability weighting in both the environmental and financial lottery choice tasks. In contrast to Riddel's (2012) findings, however, we do not observe more a pronounced curvature in the environmental weighting function than that in the financial domain. Nevertheless, our estimates for the probability weighting parameters (α_F = α_E =0.77) are very close to those obtained by Riddel (α_F = 0.77, α_E =0.70).

Further, our results also indicate that loss aversion also does not appear to be domain-specific. However, the average estimated value of loss aversion in both cases was significantly different from one supporting the thesis that respondents' choices were not consistent with EUT. In this study, the loss aversion parameters were estimated at 3.01 and 3.02 for the financial end environmental domains respectively. Tanaka et al. (2010) report a value for the loss aversion parameter of 2.63 for Vietnamese households, and Liu (2013) a value of 3.47 for Chinese farmers. However, Novemsky and Kahneman (2005) present slightly lower values of the loss aversion coefficients in financial context from studies in developed countries. In this case, a value of about 2 was reported for the loss aversion parameter.

In the survey, we included the self-reported Domain-Specific Risk-Taking (DOSPERT) scale. Associating the DOSPERT subscales together with socio-demographics to the probability weighting parameter (α) and the loss aversion parameter (λ) provides some indication of validity as age and the risk attitude towards financial activities show plausible connections. However, more evidence would be required to conclude that connections found are more than sample specific.

Overall, our results indicate that assuming EUT underpins respondent choices in stated preference surveys involving risky environmental goods may be misplaced. Given that both probability weighting and loss aversion occur, it is reasonable to conclude that prospect theory is indeed a better behavioural descriptor. However, the degree to which preference measures such as stated WTP estimates may be biased is an empirical question and our data are not sufficient to resolve this issue. Thus, in future studies it would be useful to collect additional data on respondent risk preferences and loss aversion as well as individual WTP in order to generate a body of data to address directly the question of how large (or small) such a bias might be. In addition, further research is merited in order to better understand the apparently different interactions between loss aversion and risk attitudes in the financial and environmental domains.

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