WARSAW UNIVERSITY
Warsaw Ecological Economics Center

# THE IMPACT OF RISK PREFERENCES AND LOSS AVERSION ON WILLINGNESS TO PAY TO AVOID RENEWABLE ENERGY EXTARNALITIES

Anna Bartczak, Susan Chilton, Mikołaj Czajkowski, Jürgen Meyerhoff

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# 1. INTRODUCTION

Many stated preference (SP) studies aim to evaluate public environmental goods and services acknowledge the importance of risk and uncertainty associated with individuals' decisions.

Uncertainty in SP studies can be associated with:

- scientific predictions about environmental outcomes or be connected with the effectiveness of proposed delivery mechanisms,
- environmental outcomes e.g. a conservation status of species can be risky *per se*,
- may result from the public characteristics of many environmental goods.

⇒ **If uncertainty is present in a SP study it is likely that individual's risk preferences and loss aversion may influence her willingness to pay (WTP) for an environmental good in question,**

# 1. INTRODUCTION

- Some psychological studies (e.g. Weber et al., 2002) provide evidence that individual's risk preferences can vary between financial and other domains.
- When individuals make choices in environmental SP studies they consider giving up money in exchange for improved quality or quantity of non-market (e.g. environmental) goods.
- If respondents' choices in environmental SP studies are driven by environmental risk preferences, financial or both remains an open question.
- If respondents' choices in environmental SP studies are driven by loss aversion for money also remains an open question.

# 1. INTRODUCTION

**Risk preferences in the financial domain**:

- On one hand side we can expect that people who are more risk seeking would tend to invest more in uncertain outcome,
- On the other hand, taking into account the public characteristic of some environmental goods, more risk averse individuals might choose to contribute more to the good in order to compensate for the risk of others not contributing.

# 1. INTRODUCTION

**Loss aversion in the financial domain**:

Whether the discrepancy between WTA and WTP can be explained solely by loss aversion for goods or also by loss aversion for money has been a subject of a few important studies.

- E.g. Bateman et. al. (2005) argue that there is a symmetry between WTA and WTP i.e. the acts of giving up goods when sold for money and giving up money to buy goods are both constructed as losses.
- On the other hand, Tversky and Kahneman (1991) postulate an absence of loss aversion for money in transactions (the act of selling a good for money (WTA) is constructed as a loss of the good, whereas the act of giving up money to buy goods (WTP) is constructed as a foregone gain of money, not a loss).
- Weber at al. (2007) in the study on activation of the amygdala (functional brain region responsible for processing of fear) suggest loss aversion for goods as well as an absence of loss aversion for money in routine transactions.

# 2. OBJECTIVE OF THE STUDY

The main objective of the study is to explore the impact, if any, of:

- individual's financial risk preferences,
- loss aversion elicited in a financial domain

on WTP for a non-routine good such as avoiding landscape externalities from the renewable energy development in Poland.

# 3. DESIGN OF THE STUDY

**I. Valuation – Choice Experiment** (CE) concerning renewable energy (wind, solar and biomass) externalities

- the CE comprised four labeled alternatives.
- the choice sets were created using a Bayesian efficient design
- the final design comprised 24 choice sets that were blocked into four subsets
- the order of choice sets appearance was randomized as was the order of the first three labelled alternatives.

**II. Risk preferences and loss aversion elicitation** – the multiple price list (MPL) with paired lotteries designed by Tanaka et al. (2010)

- individuals were presented with 3 series of lottery pairs (A and B) and asked to choose one lottery for each pair,
- when moving down the list of lotteries, payoffs in Option B increased while everything else was fixed.
- the lotteries were designed in a way that any combination of choices in the 3 series determines a particular interval of prospect theory parameter values

# CE DESIGN – ATTRIBUTES & LEVELS

| Attribute | Attribute label | Attribute level |
|---|---|---|
| **Minimum distance to residential areas** | Distance | 300m; 600m; 900m (FSQ); 1600m; 2500m |
| **Size of renewable energy production sites** | REPS size | small; medium (FSQ), large |
| **Number of renewable energy production sites** | REPS number | 1; 2; 3 (FSQ); 4; 5 |
| **Share of landscape not used for renewable energy expansion** | Landscape | 10%; 20%; 30% (FSQ); 40%; 50% |
| **High-voltage transmission lines** | HVTL | overhead (FSQ); underground |
| **Monthly surcharge or rebate to energy bill (annually)** | Cost | -20 zł (-240 zł); -10 zł (-120 zł); 0zł (FSQ); +5 zł (+60 zł); +15 zł (+180zł); +30 zł (+360 zł); +50 zł (+600 zł)** |

The choice experiment designed for the German project EnergyEFFAR (Oehlmann and Meyerhoff, 2016)

# CE DESIGN – CHOICE SET EXAMPLE

| | Electricity from wind | Electricity from biomass | Electricity from solar | "Do not care" |
|---|---|---|---|---|
| Minimum distance to residential areas | 600m | 2500m | 300m | 900m |
| Size of renewable energy production sites | Large (35-50 turbines) | Large (15-25 fermentation tanks) | Small (0.5 – 5 hectares) | Medium |
| Number of renewable energy production sites | 4 | 5 | 5 | 3 |
| Share of landscape not used for renewable energy expansion | 20% | 50% | 10% | 30% |
| High-voltage transmission lines | underground | underground | overhead | overhead |
| Monthly surcharge or rebate to energy bill (annually) | +30zł (+360zł) | -10zł (-120zł) | +30 (+360zł) | 0 zł |
| Choice | □ | □ | □ | □ |

## 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 |

# 4. RISK - PROSPECT THEORY (PT)

**Value function:**

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

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>1, if she is risk neutral then σ=1, and risk averse if σ<1.

$\lambda$ can take only positive values. It measures one's sensitivity to loss compared to gain. The higher the value of $\lambda$, the more loss averse an individual is.

**Probability weighting function:**

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

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

# 4. RISK – PROSPECT THEORY

**PT utility function for a two outcome gamble:**

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

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

# 5. ECONOMETRIC APPROUCH

- MXL model;
- All non-cost atrtributes were specified to follow a normal distribution; COST followed a log-normal distribution,
- Cost enters as two variables allowing for a different parameter of the marginal utility of money when one chooses an alternative with:
  - the cost to be paid ('cost positive') – SURCHARGE on a current electricity bill
  - the cost decreasing ('cost negative') - REBATE on a current electricity bill
- risk preferences and loss aversion enter the model via interaction effects with the SURCHARGE and REBATE attributes
- both $\lambda$ and σ are normalized.

# 6. DATA

- N = 800;
- quota sample representative of the Polish population in terms of:
  - gender,
  - age,
  - agglomeration size,
  - geographical location;
- carried out by a professional polling agency in January 2016;
- face-to-face, CAPI;
- subjects excluded from the analysis:
  - those who never switched in the CE and in the lottery tasks (46)

| | Share | Mean | Median | Min | Max |
|---|---|---|---|---|---|
| **Women** | 53% | | | | |
| **Age** | | 45 | 47 | 18 | 82 |
| **Education** | | | | | |
| - **Primary** | 18% | | | | |
| - **Secondary** | 54% | | | | |
| - **High** | 28% | | | | |
| **Net monthly individual income in zł** | | 4862 | 4000 | 1000 | 24500 |

Note: Nominal exchange rate 1€ = 4.36zł (January 2016)

# 7. RESULTS

| Risk preferences | Share of individuals |
|---|---|
| **Risk aversion** | 37% |
| **Risk neutral** | 36% |
| **Risk seeking** | 28% |

| Loss aversion | Share of individuals |
|---|---|
| **Loss aversion >1 (PT)** | 68% |

# 7. RESULTS

| Variable | coeff. | st.err. | p-value |
|---|---|---|---|
| ***Mean*** | | | |
| ASC_wind energy | 0.1660 | 0.2035 | 0.4148 |
| **ASC_solar energy** | **2.6512** | **0.2265** | **0.0000** |
| **ASC_biomass energy** | **-1.3059** | **0.2331** | **0.0000** |
| **Distance** | **0.4511** | **0.0684** | **0.0000** |
| REPS size | 0.0595 | 0.0714 | 0.4047 |
| **REPS number** | **0.0995** | **0.0386** | **0.0099** |
| Landscape | 0.3127 | 0.3637 | 0.3899 |
| **HVTL** | **0.2831** | **0.1082** | **0.0089** |
| **Cost positive (SURCHARGE) (Euro)** | **-1.4873** | **0.1441** | **0.0000** |
| **Cost negative (REBATE) (Euro)** | **-3.6842** | **0.6100** | **0.0000** |
| Cost positive (SURCHARGE) * $\lambda$ | 0.1321 | 0.1242 | 0.2875 |
| **Cost negative (REBATE) * $\lambda$** | **-0.7527** | **0.3872** | **0.0519** |
| **Cost positive (SURCHARGE) * $\sigma$** | **-0.3027** | **0.1216** | **0.0128** |
| Cost negative (REBATE) * $\sigma$ | -0.1728 | 0.1842 | 0.3481 |
| | | | |
| ***Standard deviations*** | | | |
| ASC_wind energy | 3.2901 | 0.2467 | 0.0000 |
| ASC_biomass energy | 2.6634 | 0.2452 | 0.0000 |
| ASC_solar energy | 3.8111 | 0.2586 | 0.0000 |
| Distance | 0.9039 | 0.0984 | 0.0000 |
| REPS size | 0.5253 | 0.1265 | 0.0000 |
| REPS number | 0.0758 | 0.1849 | 0.6820 |
| Landscape | 3.3468 | 0.6615 | 0.0000 |
| HVTL | 1.3436 | 0.1605 | 0.0000 |
| Cost negative (Euro) | 2.8753 | 0.4421 | 0.0000 |
| Cost positive (Euro) | 1.8476 | 0.1526 | 0.0000 |
| | | | |
| Number of observation | | | 756 |
| Log likelihood at convergence | | | -5670.44 |
| LL | | | -3858.46 |
| Pseudo $R^2$ | | | 0.32 |

# 8. CONCLUSIONS

- Solar energy was preferred over the proposed FSQ,
- Generating energy from biomass was valued negatively,
- Respondents preferred sites that were further away from their place of residence, although the size of sites *per se* was not that important,
- Respondents preferred the higher number of renewable energy production sites and new transmission lines built underground,
- Respondents treated the alternatives presented on the choice sets clearly differently depending on whether they would have to pay a surcharge or whether they would receive a rebate,
- Marginal utility of money seems to be lower with a rebate than with a surcharge.

# 8. CONCLUSIONS

- Financial risk preferences appeared to impact peoples’ choices in a case of a surcharge, while loss aversion for money impacts them in the case of a rebate,
- The more risk seeking people are in a financial domain they are less cost sensitive and are willing to pay more for proposed changes in renewable energy development,
- The more loss averse for money people are, they require more compensation before they accept externalities from renewable electricity production.

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Authors' contact:



| | |
|---|---|
| Anna Bartczak<br>bartczak@wne.uw.edu.pl<br><br>Mikołaj Czajkowski<br>miq@wne.uw.edu.pl | Warsaw University<br>Warsaw Ecological Economics Center<br>http://www.en.woee.pl/ |
| Susan Chilton<br>susan.chilton@newcastle.ac.uk | Newcastle University<br>Business School<br>http://www.ncl.ac.uk/nubs/ |
| Jürgen Meyerhoff<br>juergen.meyerhoff@tu-berlin.de | Technische Universität Berlin<br>http://www.tu-berlin.de/menue/home/parameter/en/ |