Erasmus Universiteit Rotterdam

Erasmus School of Economics

Master Thesis

Does Loss Aversion Exist? Experimental Evidence from Small Stakes Decisions Under Risk and Uncertainty

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Abstract

Previous studies on loss aversion have shown mixed results for small stakes decisions. This thesis provides a parameter-free measurement of the utility function of individuals. The main goal is to measure utility for both gains and losses and determine whether loss aversion can be seen in the preferences of the subjects. Additionally, the thesis provides a test of prospect theory and its central features. The results include finding loss aversion on the individual level and aggregate level. The magnitude of loss aversion is lower than previous research for higher stakes decisions. The subjects show traditional S-shaped utility; concave for gains and convex for losses. Utility is similar for risk and uncertainty. Ambiguity aversion and reflection were supported by the findings. The results highlight that loss aversion may be less stable as originally predicted. Further, the results confirm that utility is reference-dependent and reinforce the position of prospect theory as a leading theory in decision under risk and uncertainty.

Contents

1 Introduction

This thesis will study decision-making under risk and uncertainty for individuals under low stakes conditions. Economists often examine and model individual decision-making in situations with known probabilities and unknown probabilities. These two states shall be referred to as risk and uncertainty henceforth, respectively. To do this, there needs to be a theory according to which individuals give values to and choose between different outcomes. Expected utility theory is the cornerstone of modern economic decision theory. In expected utility theory, individuals transform monetary outcomes into utilities and give them weights according to the probabilities of the outcome. However, many anomalies exist where expected utility proves to be inept at describing or predicting behavior e.g. Tversky (1975); Camerer & Camerer (1995); Starmer (2000). These violations challenge the predictive and descriptive validity of the model.

Due to systematic violations of expected utility theory, prospect theory has gained acceptance in the scientific community. It takes into account that individuals' preferences are characterized by cognitive biases known to psychologists but not used in common economic theory (Kahneman & Tversky, 1979). There are four main phenomena that describe preferences according to prospect theory. The first is reference-dependence. Also, the utility for gains may be different from losses, implying loss aversion. Additionally both diminishing sensitivity and probability weighting are important characteristics of prospect theory (Kahneman & Tversky, 1979; Tversky & Kahneman, 1992). A central component of prospect theory is that agents evaluate the attractiveness of a decision in connection to a reference point, which may be the current state of affairs, change in wealth, health or any other salient issue (Kahneman & Tversky, 1979). Salient reference points are the status quo (Samuelson & Zeckhauser, 1988) or an expectation of the outcome based on rational expectations (Köszegi & Rabin, 2006). Another central feature of prospect theory is that the utility is different for gains and losses (Kahneman & Tversky, 1979). This finding is called loss aversion and shows that individuals place a higher emphasis on losses than equal gains, in terms of utility.

Loss aversion has been the subject of much research since Kahneman and Tversky made their contributions to economics. In addition to experimental decision making, loss aversion has been connected with outcomes involving health ((Bleichrodt & Pinto, 2000)) and other phenomena, for example the endowment effect ((Thaler, 1980; Kahneman et al., 1991)). It has been proposed as one of the main drivers of financial market puzzles e.g. (Mehra & Prescott, 1985; Benartzi & Thaler, 1995). Loss aversion has also been offered as a possible explanation for many real world phenomena, such as the asymmetry of price elasticities (Hardie et al. (1993)) and many other real world phenomena e.g. (Camerer, 2000; Rabin, 2000; Pennings & Smidts, 2003; N. C. Barberis, 2013).

Prospect theory states that loss aversion is a stable construct and should hold for both large and small stakes outcomes. It does not specifically address any sensitivity to the size of outcomes. In the literature loss aversion is well established for prospects involving large stakes (e.g. (Abdellaoui et al., 2007)). For small stakes the evidence is less clear. (Ert & Erev, 2013) find that individuals in their experiments do not exhibit loss aversion for small stakes prospects as predicted by prospect theory and propose that loss aversion is not a stable construct. In addition to the effect of nominal payoff, the experiments also included framing effects of the prospects (Ert & Erev, 2008); (Ert & Erev, 2013). Their claim that loss aversion may be sensitive to payoff magnitudes receives support from (Harinck et al., 2007) who find magnitude effects in loss aversion for losing money in a hypothetical coin-flip. (Ert & Erev, 2013) point out that risk aversion also exhibits sensitivity to monetary outcomes. These findings seem to indicate that loss aversion is less constant than prospect theory would suggest and for small stakes the question seems even larger, highlighting the need to take another look at small stakes decision making with the assistance of a refined method to measure prospect theory preferences without making parametric or other possibly confounding assumptions. This thesis will investigate these findings further to provide an answer to the question:

Does loss aversion exist for small stakes when measured with a non-parametric method that does not impose biases or confounding assumptions?

This thesis will utilize and draw influence from the work of Abdellaoui et al. (2007) and Abdellaoui et al. (2013) in examining loss aversion in decisions of risk and uncertainty with a measurement method that does not require parametric assumptions or other biasing factors. The method is an extension of the trade-off method by Wakker & Deneffe (1996), where utilities are elicited from subjects for both gains and losses, and then connected to evaluate the whole utility function in both domains (Abdellaoui et al., 2013). The main benefits are the ability to identify the drivers of utility with a nonparametric method. A parametric method could impose the shape and distort findings (Abdellaoui et al., 2007). In addition, nonparametric measurement methods are able to give a direct connection between the subjects' choices and utility, and allow the researcher to identify and correct possible inconsistencies in subjects' decisions.

1.1 Research Question and Contribution

The main research question in this thesis is whether individuals exhibit loss aversion when faced with small stakes prospects. It will build on the work by Ert & Erev (2008) and Ert & Erev (2013) who find that loss aversion is not seen with small stakes decisions. The subjects' utility in both the gain and loss domains should be measured and combined (Abdellaoui et al., 2007). This is done to provide a better picture on the influence of loss aversion.

The method measurement method in this thesis will be based on the model of Abdellaoui et al. (2013) for eliciting utility with a parameter-free method. The benefits of the model include the lack of assumptions needed in the measurements. This will ensure that imposing a parametric form for utility will not drive our results. In addition, the model does not require expected utility to hold. Loss aversion is widely researched but this thesis adds to the material on loss aversion for small stakes and helps to understand the nature of loss aversion as a construct. To my best knowledge, this thesis is among the first to conduct such a study for small stakes prospects while utilizing this particular method.

1.2 Outline of Thesis

The thesis will proceed as follows. First, a review of expected utility theory and common failures of this theory are presented. A description of prospect theory will follow, along with previous research conducted on loss aversion. Additionally, studies where loss aversion has not been found to be present, or has been suspect will be introduced. The main research question of this thesis is to investigate whether loss aversion exists for small stakes prospects. Additionally, the model will provide a thorough test of prospect theory preferences in students. Section three will focus on introducing the model used to study loss aversion and the experimental design. This section will naturally be followed by the analysis, results and discussion. The final section will provide a discussion into the implications of the research findings and what topics could be given additional focus in future research.

1.3 Notation

Choice tasks involve decisions over one of several prospects, all containing several outcomes of different probabilities. Preferences will be reflected by the usual notation where $\succeq, \succ, \sim$ stand for weak preference, strict preference and indifference respectively. The thesis will describe decision making situations as prospects, where the term mixed prospect refers to a decision task containing both gains and losses, and riskless a prospect with certainty of at least a zero outcome. The notation for these prospects is such that $(x, p; y)$, where outcome x is received with probability p, and y otherwise.

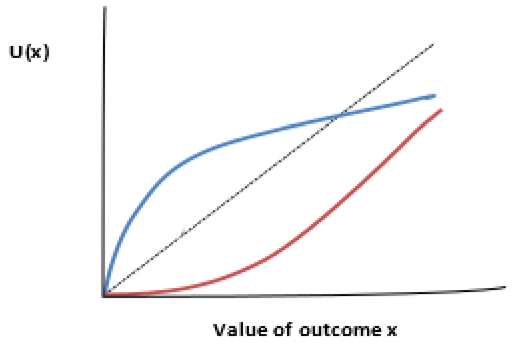
Formally, a prospect is a given probability p of earning an amount of money x such that $p = (p_1 : x_1; p_2 : x_2; \ldots; p_n : x_n)$. In discussion of prospect theory, this thesis will refer to binary prospect theory which involves prospects with two outcomes. Prospects are said to be mixed if they contain both a loss and a gain. They will be called gain or loss prospects if they contain only gains or losses. An individual is assumed to always prefer gains to losses.

2 Review of Expected Utility

Bernoulli (1738) initially purposed that choices made by individuals should not be judged according to their expected value, but that the monetary values should be transformed into subjective amounts of utility,e.g. (**?**). The transformed probabilities are then weighted by their probabilities and summed for the overall expected utility. In this decision-making model, an economic agent will make the choice that maximizes their expected utility, based on some utility function and the probabilities of outcomes. This theory is called Expected Utility Theory (EUT) and is important to review in order to form a better understanding of behavioral economics and the background of this thesis. After Bernoulli, the expected utility model was axiomatized and developed for objective or known probabilities (Von Neumann & Morgenstern, 1947) and for subjective or unknown probabilities (Savage 1954 as referenced by Savage (1972).

The utility function describes the attitude towards known probabilities (risk) of the agent. A linear function would reflect risk neutrality, concavity (convexity) risk aversion (risk seeking)(Kahneman & Tversky, 1979). Figure 1 illustrates the different shapes of utility within this theory.

Figure 1. Expected utility theory utility function. The blue curve reflects an individual with risk aversion and the red curve a risk seeking decision maker. Risk neutrality is depicted in the linear function.



An important premise of expected utility theory (EUT) is that the current wealth of the individual is integrated into their decision-making, when examining outcomes in decisions. Therefore final wealth positions are important for decision-making. The individual will maximize their utility based on the subjective utility received from a monetary outcome. All current wealth should be integrated into this decision process. According to expected utility, individuals evaluate prospects by

$$EU(p) = \sum_{i=1}^{n} p_i u(x_i) \tag{1}$$

The agent will then choose the prospect that gives them the highest value of expected utility, based on the probabilities (p_i) and outcomes x_i. Expected utility states that if an agent's preferences are described by these axioms, then the preferences can be modelled with EUT (Von Neumann & Morgenstern, 1947). The axioms include completeness, transitivity, independence, and continuity and will be described in more detail below. The following is derived from the course material of Rohde (2013) from the course Advanced Behavioral Economics of the Erasmus University Rotterdam. The Axioms were initially defined by Von Neumann & Morgenstern (1947).

Completeness: – For all Apples, Bananas we have either $Apples \succeq Bananas$, $Bananas \succeq Apples$ or both. Completeness means that an individual knows their preferences over the options presented has a clear ordering of them. Thus if the individual has a choice of apples, bananas and coconuts, they have an order of preference among these choices. It exists to maintain the stability of preferences of agents.

Transitivity: – For all Apples, Bananas, Coconuts If $Apples \succeq Bananas$ and

$Bananas \succeq Coconuts$, then we must have that $Apples \succeq Coconuts$. As an example, transitive preferences mean that if an agent strictly prefers apples over bananas and bananas over coconuts, then they must strictly prefer apples over coconuts.

Continuity: – For all Apples, Bananas, Coconuts where $Apples \succeq Bananas$ and $Bananas \succeq Coconuts$ there must exist a probability p such that $(p : Apples; (1-p) : Coconuts) \sim Bananas$. Verbally this means that if Apples are preferred to Bananas and Bananas to Coconuts, then there must be a probability p for which the agent is indifferent between a combination of Apples and Bananas, and Coconuts.

Independence: – For all Apples, Bananas, Coconuts if $Apples \succeq Bananas$, then $(p : Apples; (1-p) : Coconuts) \succeq (p : Bananas; (1-p) : Coconuts)$. The independence axiom means that preferences should remain stable, even when combinations of the options are presented. The independence axiom is one of the main failures of expected utility theory (Tversky, 1975).

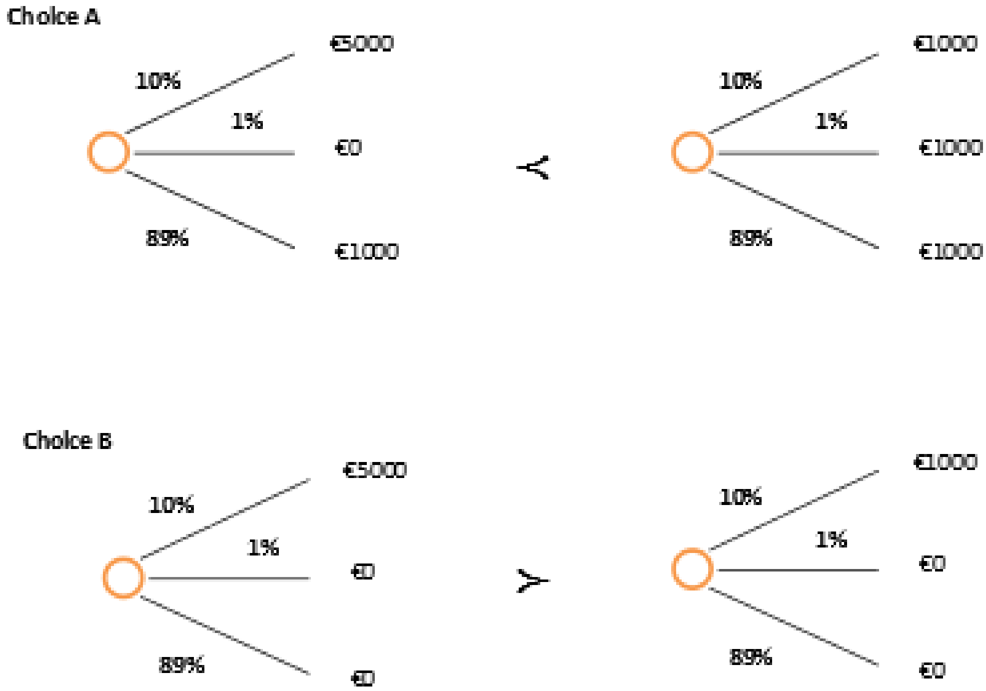
Although widely used in economics, a significant amount of choice tasks exist where subjects have been found to violate one or many of these axioms and therefore expected utility theory. If an individual does not satisfy these axioms, then their preferences cannot be reliably predicted by expected utility and would lead to incorrect predictions. This creates a large problem with using models where expected utility is assumed to hold. The most famous or notable violations of the axioms will be discussed in the following section.

2.1 Evidence for Violations of EU

In experiments of decision making, subjects have been found to violate expected utility in several different ways. A classic example of violating the independence axiom is the Allais' Paradox (Allais, 1979), where an agents' preference between two prospects is reversed after eliminating a common outcome. This is a clear violation of independence and shows a systematic failure of expected utility to predict choices correctly.

An example of the Allais' Paradox is provided in figure 2. In the figure, an individual first chooses between two gambles in task A. In this task they prefer a certain outcome of EUR1000 over a risky gamble. In choice task B, we have eliminated one common outcome, otherwise keeping the choices constant. By independence, the agent should still have the same preferences. However, through experiments, Allais' along with (Kahneman & Tversky, 1979) were able to show that individuals reverse their initial preference.

Figure 2. An example of the Allais paradox, or common consequence effect (Kahmen & Tversky 1979). Figure adapted from the course Advanced Behavioral Economics at the ESE (Rohde 2013).



Another famous violation of expected utility is the common ratio effect, where a similar preference reversal can be observed after multiplying the probabilities of outcomes with a common ratio. The preferences of individuals are also highly dependent on the framing of outcomes (Kahneman & Tversky, 1979). Description invariance is a preference reversal that occurs after the framing of the outcome is changed. No real changes between the outcomes are imposed. For example, consider a disease that is expected to be terminal for 1000 people. The subjects have a choice between of spending on one of two medical research programs A or B. Program A is such that adopting the program will save the lives of 600 people for sure. In program B the likelihood of saving everyone is 1/3, whereas the likelihood of everyone dying is 2/3. The majority will choose program A, where they opt to save 600 with certainty. If the framing of these options is altered such that the first alternative becomes that the results in 400 casualties with certainty, the majority of subjects will reverse their preferences. This finding reflects the framing effect of the outcome; people seem to be willing to take more risks if program A is presented as a loss (certain casualties), than as a gain (certain survivors). These results prompted the development of prospect theory, that better reflects the psychology behind decision-making (Kahneman & Tversky, 1979; Tversky & Kahneman, 1992) and addresses the inconsistencies highlighted in the research.

3 Prospect Theory

Prospect theory emerged successful through its descriptive ability in decision making behavior. It emerged as an alternative to normative models relying on expected utility, which were the dominating models used by economists for making evaluating agents' preferences and behavior (Kahneman & Tversky, 1979). Kahneman & Tversky (1979) and Tversky & Kahneman (1992) assert that individuals evaluate prospects based on the utility of deviating from a reference point weighted with the transformed probability, or decision weight. The theory extends the Rank-Dependent Utility (RDU) (Quiggin, 1982), where outcomes are ranked according to their size, from lowest to highest (see also Quiggin (1991). However, a drawback of this method was the assumption that individuals integrate current wealth or assets into their decision making, en empirical fact shown to be inconsistent. Prospect theory adapted RDU to incorporate a reference-point that influences individual preferences. The original version of PT had an inherent flaw in that the functional violated stochastic dominance (Kahneman & Tversky (1979); Fennema & Wakker (1997)). The violations were later corrected in Cumulative Prospect Theory (Tversky & Kahneman, 1992).

3.1 Binary Prospect Theory

In this thesis, binary prospect theory will be used where individuals are presented with choices with two outcomes x and y. Prospects are called mixed if they contain both a loss and a gain. In a case where there are only gains or losses, the term used is gain or loss prospect. In binary prospect theory, a decision maker evaluates mixed prospects under risk x_py by

$$w^+(p)U(x) + w^-(1-p)U(y) \tag{2}$$

where w^i are the decision weights, reflecting the tendency of individuals to transform objective probabilities to reflect their attitudes to probabilities. In the elicitation method used in this thesis, x_0 will reflect the reference point, and the value of x_0 is set to be 0. The decision-maker evaluates gain or loss prospects under risk x_py by

$$w^i(p)U(x) + (1-w^i)U(y) \tag{3}$$

where $i = +$ for gains and $i = -$ for losses. The decision-maker will then determine which prospect to prefer based on these functions and will choose the prospect that yields a higher value of the comparison.

3.2 The Value Function

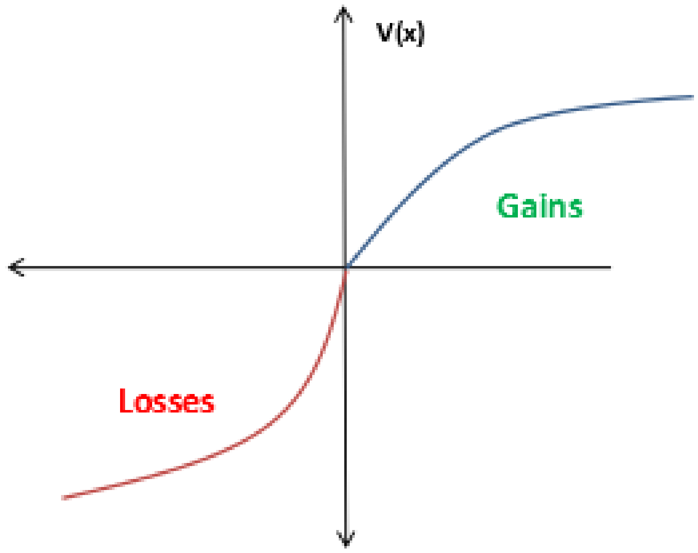
The value function represents the decision-makers' valuation of an outcome, which in this thesis is monetary. The value function is described by diminishing sensitivity and loss aversion (Kahneman & Tversky, 1979). The former can be seen in the curvature of the value function in both gain and loss domains, the latter is seen in the difference of slopes between gains and losses relative to a reference point (Kahneman & Tversky, 1979). Reference-dependence is a central feature of prospect theory; agents do not integrate assets into their decision making as in Rank-Dependent Utility or Expected Utility Theory. Utility is driven by changes in states, not absolute outcomes (Kahneman & Tversky (1979)). (Samuelson & Zeckhauser, 1988) offer the status quo as a salient reference point. Other suggested reference points could be formed around the expectation on the outcome based on rational expectations (Köszegi & Rabin (2006)). Agents then evaluate and make decisions taking into account the reference point. This influences whether an outcome is felt as a gain or a loss. The origin of the piecewise utility function is formed by the reference point, where utility for gains is different from utility for losses by parameter λ. In short, they state that the satisfaction of a gain is less than the negative emotions experienced with an equal loss, leading agents to be averse to choices including losses. Tversky & Kahneman (1992), describe a agents' value function as

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

The parameter value $\lambda > 1$ reflects loss aversion, and the parameter α the diminishing sensitivity to increases in absolute values of the payoffs. Specifically, Tversky & Kahneman (1992)) proposed a coefficient of loss aversion of $\lambda = 2.25$.

The coefficient α reflects diminishing sensitivity and gives the function its' concave (convex) shape for gains (losses), where $\alpha = 0.88$. Contrary to expected utility theory, the concavity (convexity) does not necessarily reflect the agents' risk attitude, because of the probability transformation of prospect theory. Kahneman & Tversky (1979) state that decision-makers are inherently reluctant to participate in symmetric gambles of equal probabilities to win or lose EUR100. Losses appear to play a larger role preferences than equal gains.

Figure 3. Prospect Theory value function. The piece -wise function reflects the difference in utility from equal gains and losses through the steepness of the slopes.



For gains, research results support prospect theory and find that most subjects have concave utility for gains and convex (or linear) for losses (Abdellaoui et al. (2013)). Many studies have evaluated the subjects' utility functions by assuming expected utility holds (Abdellaoui et al. (2007)), and had a large fraction of subjects for whom utility was concave in the loss domain instead of convex as predicted by prospect theory (Fishburn & Kochenberger (1979); (Pennings & Smidts, 2003)). It may be that the assumption of expected utility influenced the utility function in favor of convexity for large portion of subjects, still leaving many with concave utility for losses (Abdellaoui et al. (2007)).

Utility for losses was found to be linear when small stakes are present in the gambles (e.g. Abdellaoui et al. (2013); Vieider et al. (2013)). Further studies that examined utility for prospect theory were conducted by e.g. (Tversky & Kahneman, 1992; Abdellaoui, 2000; Abdellaoui et al., 2007, 2013; Booij & van de Kuilen, 2009). Much research have observed similar results to Tversky & Kahneman (1992), where they found a median power coefficient of 0.88. However, many subjects also had linear or concave utility for losses.

3.3 Probability Weighting

In addition to proposing a reference-dependent piecewise value function, Tversky & Kahneman (1992) state that agents do not process probabilities of events objectively, but transform them to subjective decision weights. The probability weighting function represents the decision-makers attitude towards probabilities (Fennema & Wakker, 1997). It does not mean that they do not understand probabilities; it merely means that they assign a different subjective weight to this outcome than the objective probability (N. C. Barberis, 2013). Through testing, (Tversky & Kahneman, 1992) found that individuals seem to assign unrealistically high weights to low probabilities. Consider a prospect of the form $(x, p : y)$, where an individual receives outcome x with probability p, and y otherwise. They showed that for the gambles A and B where $A = (5000, 0.01 : 0)$ and $B = (5, 1)$ subjects preferred A over B. This preference highlights that low probabilities are assigned higher decision weights than the objective probability.

The result of the findings of Tversky & Kahneman (1992) is the inverse S-shaped probability weighting function for cumulative prospect theory shown in figure 4. Diminishing sensitivity can be seen as high sensitivity to differences in extremes $[0, 1]$ but smaller sensitivity to differences in the medium range of probabilities (Fennema & Wakker, 1997). For low probabilities the assigned weights are higher than the objective probabilities. For high probabilities, the contrary applies. The probability weighting function gives insight into risk attitudes as well, reflecting e.g. overoptimism and conservatism. The characteristics and form of the probability weighting function have been observed in numerous studies. Their results give extra strength to the statement that individuals value probabilities differently than the objective likelihood would imply e.g. (Tversky & Kahneman, 1992; **?**; Tversky & Fox, 1995; Wu & Gonzalez, 1996; Gonzalez & Wu, 1999; Abdellaoui, 2000; Bleichrodt & Pinto, 2000).

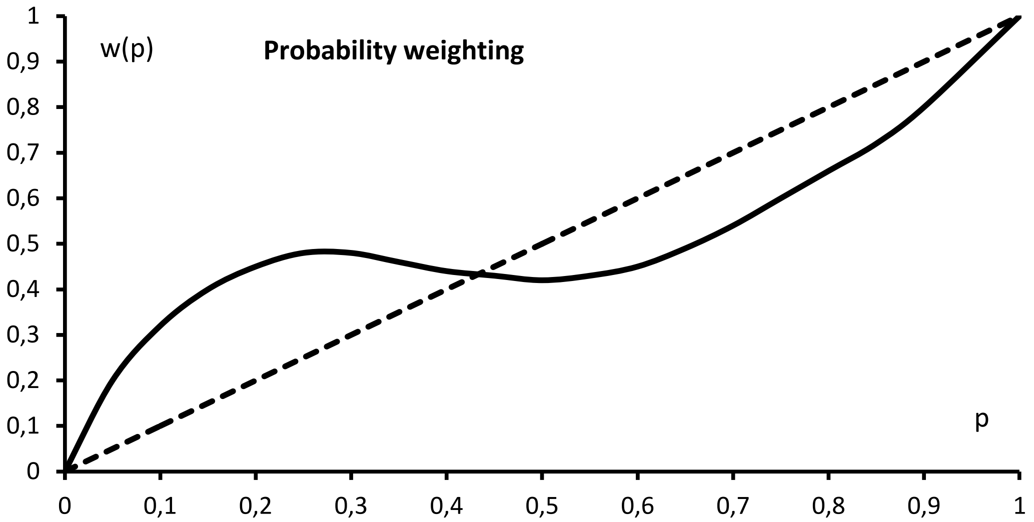


Figure 4: The probability weighting function by Tversky and Kahneman (1992) shows that agents convert objective probabilities to decision weights. General features of the probability weighting function are the overweighting of small probabilities and underweighting high probabilities.

3.4 Loss Aversion

According to Kahneman & Tversky (1979), the definition of loss aversion is $-U(-x) > U(x)$, for all $x > 0$. In figure 3, loss aversion can be seen as the difference between the slopes of the value function for gains and losses. Köbberling & Wakker (2005) define loss aversion as the kink in the value function. The coefficient of loss aversion implied by prospect theory is $\frac{-U(-x)}{U(x)}$, for $x > 0$, as stated by Abdellaoui et al. (2013). The definition is similar to Benartzi & Thaler (1995), who define loss aversion as a characteristic of utility around the reference point. This loss aversion index builds on the original definition by Kahneman & Tversky (1979) and states that the loss aversion index is the ratio of the left derivative and right derivative around 0. Formally the definition is such that: $\lambda = \frac{-U_{\uparrow}(0)}{U_{\downarrow}(0)}$. Wakker & Tversky (1993) present a definition of loss aversion where the slope of the utility function is at least as steep for losses as it is for gains. The definition is such that $U'(-x) \geqslant U'(y)$ for positive x and y.

The coefficient of loss aversion found by Tversky & Kahneman (1992) is 2.25. Many studies have resulted in similar findings, where this coefficient revolves around 2. However, a difficulty in comparing these studies is that a unified definition of loss aversion has not been generally approved, and that these studies all make different assumptions in their testing method Abdellaoui et al. (2013)). This thesis will show coefficients of loss aversion by Kahneman & Tversky (1979) and Köbberling & Wakker (2005).

3.5 Empirical Findings on Loss Aversion

Loss aversion has been widely documented for high stakes decisions, where the monetary amounts are large. Abdellaoui et al. (2013) conducted a thorough test of prospect theory under both risk and uncertainty and found evidence of loss aversion in its many definitions with high stakes. However, there are questions into the persistence of loss aversion for small stakes. Using loss aversion as suggested Wakker & Tversky (1993), Schmidt & Traub (2002) found in their experiment that 24 percent of their subjects were not loss averse, or they were classified as "gain-seeking" (Abdellaoui et al. (2007)). (Ert & Erev, 2008)) performed experiments on mixed gambles for students at the Technion University with small stakes and did not find loss aversion. (Ert & Erev, 2008) and (Ert & Erev, 2013) highlight the sensitivity of loss aversion to framing effects as well as nominal amounts. Low nominal payoffs do not appear to trigger loss aversion, whereas high nominal payoffs have a significant effect on preferences. Novemsky & Kahneman (2005) pointed out that loss aversion may not be present if goods are exchanged as intended. This finding relies on the perception of losses not being present when one acts in accordance with a previous plan or intentions.

The findings of these studies seem to indicate that loss aversion is indeed less constant than originally suggested by prospect theory. For small stakes the question seems even larger, highlighting the need to take a closer look at small stakes decision-making with the assistance of a refined method to measure prospect theory preferences without making parametric or other possibly confounding assumptions. The method of (Abdellaoui et al., 2013) will be used to test preferences for small stakes in students of the Erasmus University. This method is an adaptation of the trade-off method by (Wakker & Deneffe, 1996) and will be further in the following section.

4 Measurement Method

Tis section of the thesis will focus on the method used to investigate the utility functions of the subjects. The procedure consists of three stages. First the general details for the procedure are stated, after which we will discuss the experimental design. The method used in this thesis was developed from the tradeoff method of Wakker & Deneffe (1996) by Abdellaoui et al. (2013). The experimental procedure is comparable to Abdellaoui et al. (2013) where they employed their method to investigate attitudes towards ambiguity and risk attitudes as well as loss aversion for large stakes. The procedure will differ in that the chosen fixed values will reflect small stakes outcomes.

In this method, indifferences are elicited for gains and losses to examine the utility

		Assessed Quantity	Indifference	Choice variables
Stage 1		L	$G_pL \sim x_0$	$G = 10$ euro
		x_1^+	$x_1^+ \sim G_p x_0$	E =color of ball from urn
		x_1^-	$x_1^- \sim L_{1-p} x_0$	$p = 0.5$
Stage 2	Step 1	$\mathscr{L}$	$x_1^+{}_p\mathcal{L} \sim l_{1-p} x_0$	
	Step 2 to k$_G$	x_j^+	$x_j^+{}_p\mathcal{L} \sim x_{j-1}^+{}_{1-p} l$	$l = -1.5$ euro ; $k_G = 5$
Stage 3	Step 1	$\mathcal{G}$	$\mathcal{G}_p x_1^- \sim \mathrm{g}_{1-p} x_0$	
	Step 2 to k$_L$	x_j^-	$\mathcal{G}_p x_j^- \sim \mathrm{g}_{1-p} x_{j-1}^-$	$\mathrm{g} = 1.5$ euro ; $k_L = 5$

of the subjects in both domains (Abdellaoui et al., 2013). The method consists of a three-stage procedure. In the first stage, we will elicit a gain and loss, that have the same absolute value in utility. These values will be used to connect the utility for gains with the utility for losses. The utility for gains is measured in the second stage of the procedure, whereas the utility for losses will be measured in the third stage. (Wakker & Deneffe, 1996) based their tradeoff method on the notion that they are able to determine a standard sequence of outcomes. In these sequences, the distance between the different outcomes is equal in utility. The distance also remains constant throughout the sequence. In addition, as we are able to set $u(0) = 0$ and $u(1) = 1$, we are able to obtain a representation of the utility function ((Abdellaoui et al., 2013); (Wakker & Deneffe, 1996)). As stated by Abdellaoui et al. (2013), the measurement of loss aversion requires measuring utility for both gains and losses. With this method we are able to do so. In addition, it is possible to evaluate loss aversion under its numerous different definitions. An additional benefit of this method is that no parametric assumptions are imposed for the subjects utility or weighting of probabilities(Abdellaoui et al., 2013).

In the first stage, the process begins by selecting a probability for an outcome under risk, or an event for outcomes under uncertainty. They are denoted respectively with p and E. The probabilities and event E will remain unchanged throughout the first stage. In addition, we will fix a gain G to be used in the first stage for eliciting the indifferences. We will use the gain G to elicit the loss L for which the subject is indifferent between the risky prospect and x_0, such that $G_pL \sim x_0$. Previously we have stated that under binary prospect theory, prospects are evaluated according to (1). It follows from this equation that:

$$w^+(p)U(G) + w^-(p)U(L) = U(x_0) = 0 \tag{4}$$

Following this, we elicit the values x_1^+ and x_1^- such that a) $x_1^+ \sim G_p x_0$ and b) $x_1^- \sim L_(1-p)x_0$. The first indifference a) implies that:

$$U(x_1^+) = w^+(p)U(G) \tag{5}$$

The second indifference b) similarly implies that:

$$U(x_1^-) = w^-(1-p)U(L) \tag{6}$$

Combining equations (2) – (4) gives us

$$U(x_1^+) = -U(x_1^-) \tag{7}$$

As stated by Abdellaoui et al. (2013) equation (5) determines the first parts of the standard sequence. These elements will be used in the second and third stages similarly to the tradeoff method by Wakker & Deneffe (1996). For uncertainty, the probability p will be replaced by an event E and the decision weights become $W^+(E)$ and $W^-(E^c)$.

The second stage involves eliciting a standard sequence of gains similarly to the tradeoff method by Wakker & Deneffe (1996). In this stage, we fix ℓ as a loss that will be held constant. Then we elicit the loss $\mathscr{L}$ such that $x_1^+{}_pL \sim l_{1-p}x_0$. Chaining is used so that the value x_1^+ is the same as elicited in the first stage of the process. For binary prospect theory, this indifference implies that

$$w^+(p)U(x_1^+) + w^-(p)U(\mathscr{L}) = w^-(p)U(\ell) \tag{8}$$

As we are able to set $x_0 = 0$, we can thus rearrange equation (6) that

$$U(x_1^+) - U(x_0) = \frac{w^-(p)}{w^+(p)}(U(\ell) - U(\mathscr{L})) \tag{9}$$

Following this procedure, we similarly elicit the value for the gain x_2^+ and obtain the indifference $x_2^+{}_p\mathscr{L} \sim x_1^+{}_p\ell$. It is straightforward to see that analogously to Eq. (7), this can be rearranged as

$$U(x_2^+) - U(x_1) = \frac{w^-(p)}{w^+(p)}(U(\ell) - U(\mathscr{L})) \tag{10}$$

Combining this equation (10) with equation (9) gives us the following:

$$U(x_2^+) - U(x_1) = U(x_1^+) - U(x_0) \tag{11}$$

This is now followed by a similar procedure to elicit the indifferences $x_j^+{}_pL \sim x_{j-1}^+{}_p\ell_p$ from $j = 2, \ldots, k_G$. By this we are able to find a string of values $(x_0, x_1^+, x_2^+, \ldots, x_{k_G}^+)$. Analogously to our prior steps, we find that $U(x_j^+) - U(x_{j-1}^+) = U(x_1^+) - U(x_0)$, for all j. This means that the distance between the values is equally spaced in utility (Abdellaoui et al., 2013).

For the third stage, a standard sequence of losses is constructed using a similar method to stage two. In this, we first fix a gain g and probability p (event E for uncertainty). Next we elicit a gain $\mathcal{G}$ such that $\mathcal{G}_p x_1^- \sim \mathrm{g}_p x_0$. The procedure is identical to the second stage in that we elicit a sequence of values $(x_0, x_1^-, x_2^-, \ldots, x_{k_L}^-)$.

In the procedure of Abdellaoui et al. (2013) we now combine the second and third stages, and order the outcomes from worst to best, such that $(x_{k_L}^-, \ldots, x_1^-, x_0, x_1^+, \ldots, x_{k_G}^+)$ where x_0 represents the reference point with value 0. Throughout the standard sequence, the differences in utility remain constant among the values. Although we are able to scale the sequence arbitrarily, it is common practice to set the utility of the largest outcome to 1. Therefore we set $x_{k_G}^+ = 1$.

5 The Experiment

5.1 Experimental set-up

The experiment was held at the Erasmus University Rotterdam Behavioral Economics Laboratory during the course of two consecutive days. The main intention of the experiment was to elicit the utility function for the gain and loss domains, according to the procedure presented in the previous section. A total of 122 subjects attended, with 46 during the second day. All subjects were students ranging from social sciences, management and economics. In total, 50 subjects were female and 72 male. The experiment was divided into several sessions per day. A maximum number of subjects per session were 20 and a minimum number 10. The experiments were overseen by three persons, who could assist the subjects in questions or problems with the program. The subjects received a show-up fee of EUR10 after they had completed the experiment. The experimental design has previously been used by Abdellaoui et al. (2013). The only major changes were the size of the monetary stakes used. Abdellaoui et al. (2013) investigated differences in utility between ambiguity and risk, and were worrisome of the possible inability to detect differences in utility with very small stakes. Wakker & Deneffe (1996) propose that utility is approximately linear over small intervals. However, in this thesis, the main objective is to try to observe whether loss aversion persists in these small stakes.

The subjects were invited into the behavioural laboratory as a group and assigned a computer in a random order. The experiment was run on the computer, and subjects made their choices using the mouse, by selecting their preferred option from A and B. After the subjects were seated, the procedure was explained by one experimenter. The subjects were instructed to consult with the experimenters if they encountered any problems or questions, and they were reminded that there are no correct or incorrect ways to respond to the experimental tasks. The average session length was 40 minutes.

In the procedure, utility was measured for both risk and uncertainty. The order in which the measurement was conducted was randomized. In the uncertainty condition, subjects were given a choice of ball to bet on, but no information on the ratios of red and black balls in the urn consisting of 10 balls. In the risk condition, subjects chose to bet on drawing either a red or black ball from an urn with 5 red and 5 black balls. The probability of drawing either is thus 50 percent.

Even though the experiment involved small stakes, the decision tasks remained hypothetical. In the procedure, subjects can influence the size of the amounts, and giving real incentives might inflate the monetary amounts. In addition, as utility is measured over both gains and losses, it would be difficult to find subjects willing to incur monetary losses in the name of science.

As stated by (Abdellaoui et al., 2013) using elicitation procedures instead of directly asking for indifference values has been proposed to be a more reliable method (Bostic et al., 1990; Noussair et al., 2004). In the elicitation procedure, indifference values were not asked directly. The subjects were given a series of questions on the binary choice task. They would narrow down the interval of their indifference value three times. After narrowing the interval three times, they would see a scroll bar, with which to make a more detailed choice on the narrow interval before confirming a final choice. If this final choice did not satisfy the subject, they would begin the process from the beginning.

5.2 Experiment details

A number of parameters were preset in order to perform the experiment, following the procedure by Abdellaoui et al. (2013). The values used by Abdellaoui et al. (2013) were divided by 200 to obtain low stakes values which help ensure comparability of results. The values are preset values can be seen from the table in section 4. In addition, the Appendix contains visualizations of what subjects' choice tasks were like, as well as examples of the experiment screens.

In the experiment, five points of the utility function were elicited to obtain descriptive depiction of the shape of each subjects utility over both domains. The procedure remained similar for both risk and uncertainty. Subjects made a decision between two prospects, which were called A and B. The subjects would find a value for indifference through zooming in on the interval that contained their direct indifference value. After the subjects had narrowed down the interval, they were presented with a scrollbar, where they could make smaller adjustments to their indifference value with their keyboard or mouse. The scrollbar began from the middle point of the interval previously selected by the subject. If the subjects were unhappy with the final choice after this process, they could cancel their choice and begin the zooming process from the first step. If they agreed that their choices were in fact in line with their preferences, they would continue to the next elicitation.

To test for consistency, some elicitations were repeated during the procedure. In the long string of gain elicitations, the third choice, x_3^+ was elicited a second time. This procedure follows from Abdellaoui et al. (2013), where they repeated the elicitation x_3^+. The results of the consistency checks and other analyses will be presented further in the thesis. As the experimental procedure is not the simplest for the subjects, the consistency checks help make sure that that data quality is usable and subjects do not violate stochastic dominance.

6 Analyses

6.1 Utility curvature

The curvature of utility has been investigated by examining the area beneath the utility function in both domains (Abdellaoui et al., 2013). Analogously to Abdellaoui et al. (2013) the domain of U was normalized to $[0, 1]$. This was achieved through the transforming of each gain x_j^+ to $\frac{x_j^+}{x_5^+}$. Following this procedure, every loss x_j^- was transformed to $\frac{x_j^-}{x_6^-}$. Linear utility would mean the area under the utility curve in both domains equals 0.5. For gains, the utility function is concave if the value of the area measure is larger than 0.5 beneath the function. Contrarily, the classification is convex if this value is smaller than 0.5. For losses, if the area below the function is greater than 0.5, the utility function is convex. The opposite also holds, in that the categorization is concave if the area measure is smaller than 0.5

In addition to the calculation of the area under a normalized utility curve, the curvature will be analysed by parametric estimation. In this method, the power family x^α is used, similarly to previous research on prospect theory (e.g. (Kahneman & Tversky, 1979),Abdellaoui2013. The parameter α is the variable that controls the curvature of the utility function for both gains and losses. For gains, $\alpha > 1$ means the utility function is convex. If $\alpha < 1$ the utility function is concave. In the loss domain utility is concave if $\alpha > 1$ and convex if $\alpha < 1$, for $-(-x)_?alpha$. Logically, $\alpha = 1$ corresponds to linear utility in both domains.

6.2 Loss aversion

In the beginning of this thesis, it was identified that loss aversion has numerous different definitions. Similarly to Abdellaoui et al. (2013), the definition by Kahneman & Tversky (1979) and Köbberling & Wakker (2005) are best suited for investigating our question. These two definitions are general, whereas other definitions may be more strict. Strictness implies that more subjects would not be classified as loss averse, and would make the task of investigating loss aversion difficult.

Loss aversion was defined by Kahneman & Tversky (1979) as $-U(-x) > U(x)$ for all $x > 0$. This essentially means that the disutility of a loss x is greater than the utility of gain x. Subjects are categorized as loss averse if $\frac{-U(-x)}{U(x)} > 1$. If $\frac{-U(-x)}{U(x)} = 1$ the subjects are classified loss neutral and finally, gain seeking if $\frac{-U(-x)}{U(x)} < 1$. The coefficient of loss aversion is computed for all observations. The definition of Köbberling & Wakker (2005) is as a kink in the utility function at the reference point, which here is 0. In the beginning of the thesis, this definition was introduced as $\frac{-U_\uparrow(0)}{U_\downarrow(0)}$. Analogously to Abdellaoui et al. (2013) this definition is analysed by computing the individual coefficients of loss aversion as $\frac{-U(x_1^-)}{x_j^-}$ divided by $\frac{x_1^+}{x_1^+}$. This definition involves x_1 and x_j^- because they are the elicitations closest to the reference point on both sides. As $U(x_1^-) = -U(x_1^+)$ the ratio becomes $x_1^+ = x_1^-$. If $\frac{x_1^+}{x_1^-} > 1$ the subject is regarded as loss averse. Conversely, if $\frac{x_1^+}{x_1^-} < 1$, the subject is regarded gain seeking. Loss neutrality results from $\frac{x_1^+}{x_1^-} = 1$ (Abdellaoui et al. (2013)).

In this thesis, loss aversion was analysed at both the aggregate level with median data as well as individual level. The coefficients of loss aversion according to Kahneman & Tversky (1979) and Köbberling & Wakker (2005) are used as reference and compared to the original findings, as well as the findings of (Abdellaoui et al. (2013)).

7 Results

A total of 122 subjects completed the experiment. Only one subject showed signs of violations of first-order stochastic dominance. Violations of stochastic dominance can be taken as an indication of not understanding the experimental task, or lack of effort in the task (Abdellaoui et al., 2013). This subject was excluded from the analysis. The subsequent analysis includes the results from 121 subjects.

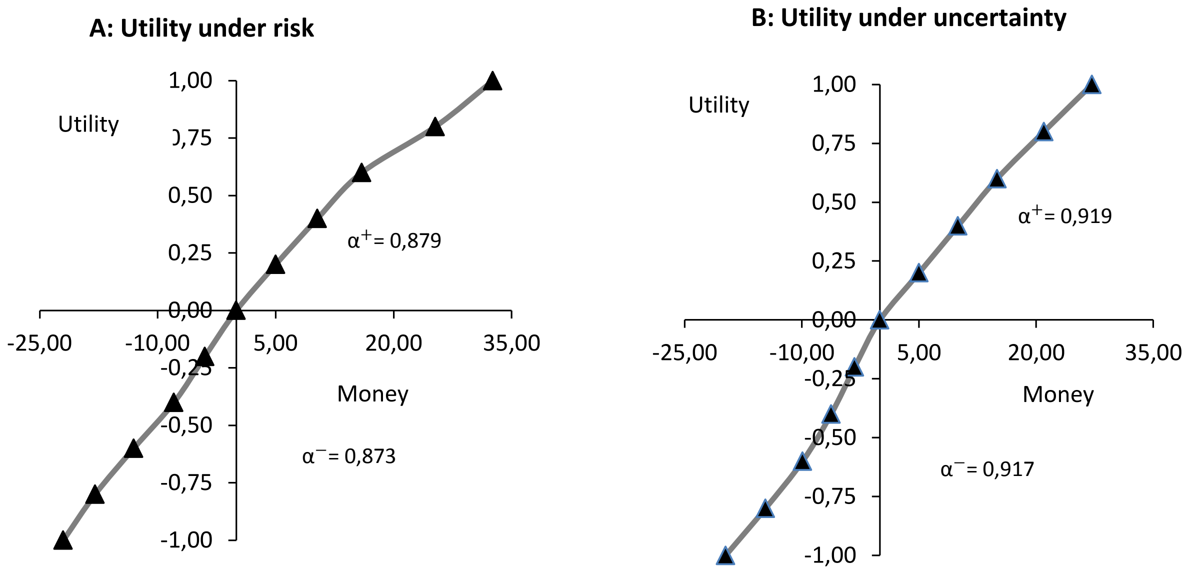
7.1 Consistency checks

Consistency of responses was investigated by repeated measurement of the third iteration. In general, the consistency was good. Subjects made the same decision in 80.33 percent of the repeated choices. The third iteration was used as (Abdellaoui et al. (2013))) point out that subjects are likely close to indifference at this point, and were more likely to reverse their preferences. In addition to checking the third iteration, x_3^+ was repeated. The correlation between the original measurement and the repeated measurement was 0.737 for risk and 0.817 for uncertainty. The results differ slightly from (Abdellaoui et al. (2013)) where they found correlation coefficients closer to unity. However, they are still significant here and are satisfactory.

7.2 The utility for gains and losses

The following figure gives the results for the shape of the utility for all subjects. The analysis is based on median data. Graph A shows the shape of the utility curve over gains and losses for the risk condition, where probabilities are known to the subjects. Visual inspection of the curve finds slight concavity in the gains domain and convexity in the loss domain. Furthermore, the slope of the curve for the loss domain appears steeper than for the gain domain, providing hints of loss aversion. The curvature of the graph is confirmed by the power coefficient α for both gains and losses. Kahneman & Tversky (1979) resulted in $\alpha = 0.88$. Here $\alpha = 0.879$ for gains and $\alpha = 0.873$ for losses. We can conclude that we find concave utility for gains and convex utility for losses in the results for risk, as predicted by Kahneman & Tversky (1979)). Graph B shows a similar curve for uncertainty. Again, visually, the curve appears to exhibit signs of concavity for gains and convexity for losses, as envisioned by prospect theory. Under uncertainty, the curvature is less pronounced for both domains. For gains, $\alpha = 0.919$ and for losses $\alpha = 0.917$. Both power coefficients are larger than suggested by Tversky & Kahneman (1992)). In addition to observing the characteristics of the power coefficient, we are able to see that the slope of the curve in the loss domain is steeper than in the gains domain. Again, this gives initial evidence of the presence of loss aversion at the median level.

Figure 5: The utility for gains and losses for risk and uncertainty. This figure shows the utility function under risk and uncertainty under prospect theory, based on median data. α^i gives the power coefficient for gains when i = + and for losses when i = -. The risk and uncertainty conditions are shown in panels A and B respectively.



The median data provides us with clues to the shape of the utility and presence of loss aversion. However, to verify this we will now move on to analysis on the subject level. The following table shows the classification of individuals' utility function for gain and loss domains. The research by Abdellaoui et al. (2013) found no differences between the classification of subjects' utility for risk and uncertainty. However, here there are some differences. More subjects have convex utility for losses for risk than for uncertainty. In addition, the number of subjects with concave utility for losses is larger for uncertainty. Both groups have the same number of subjects with linear utility. The results highlight that utility is indeed experienced differently around a reference point. As a consequence we may observe that utility for losses is quite different from the utility for gains. This would also give cause to reject expected utility theory in this context. Similar results were found by Abdellaoui et al. (2013). They found that less than 20 percent of the subjects had concave utility in both domains.

In prospect theory, individual utility is characterized by the S-shaped curve. This shape can be found in the results of 65 subjects under risk and 59 subjects under uncertainty. Thus slightly more than half of the subjects had S-shaped utility. There are no significant differences in utility curvature for the gains domain between risk and uncertainty (Wilcoxon 0.4132). However, the same test gave indication of differences between utility curvature for losses between the two conditions (Wilcoxon 0.0063). The correlation between the risk and uncertainty conditions for gains was only slight with Kendall's $\tau = 0.276$ for gains and $\tau = 0.269$ for losses.

Table 2: Classification of subjects based on the shape of their utility function. The method is b on calculating the area under the normalized utility function. Panel A shows the results for th condition and panel B for the uncertainty condition.

Panel A: Risk				
	Losses			
Gains	Concave	Convex	Linear	Total
Concave	20	57	1	78
Convex	13	19	0	32
Linear	2	1	9	12
Total	35	77	10	122

Panel B: Uncertainty				
	Losses			
Gains	Concave	Convex	Linear	Total
Concave	25	44	2	71
Convex	19	19	2	40
Linear	2	4	5	11
Total	46	67	9	122

Table 3: Individual Parametric fittings. Results of the subject level parametric fittings on each subject's choices. The median and interquartile range are in the first column. The table contains results for both risk and uncertainty.

	Risk		**Uncertainty**	
	Gains	Losses	Gains	Losses
Median	0,887	0,858	0,921	0,921
IQR	0,708-1,01	0,660-0,1026	0,752-1,068	0,696-1,159

7.3 Ambiguity aversion

A thorough examination of prospect theory preferences warrants a closer look at ambiguity aversion. In this thesis, the method for examining ambiguity aversion follows the Abdellaoui et al. (2013), which will be discussed below. They state that measurement of L and x_1^+ in stage 1 give indication for subjects' ambiguity aversion. Ambiguity aversion should be reflected in the values of L_r and L_u, the values of L for risk and uncertainty respectively. As $20_{.5}L_r \sim x_0$ and $20_{.5}L_u \sim x_0$, a subject is ambiguity averse if $20_{.5}L_r \succ 20_{.5}L_u$. As a result of transitivity, $20_E L_u \succ 20_E L_r$. The median elicited values for L_u and L_r were -8.625 and -10 respectively. From these values, we can see that $L_u > L_r$. In the experiment, 44.3 percent of the subjects showed ambiguity aversion. The result was significant (Wilcoxon 0.0214

In the measurement of $x_{1,r}^+$ and $x_{1,u}^+$ ambiguity aversion can be seen when the value of $x_{1,r}^+$ is greater than the value $x_{1,u}^+$. The median elicited value for both was 5.00. Therefore, we could not see differences for x_1^+ between risk and uncertainty (Wilcoxon 0.1858)

7.4 Loss aversion

To analyze loss aversion, the following figure shows the median data from x_j^+ and x_j^- and compares them to the absolute value of utility derived from either.

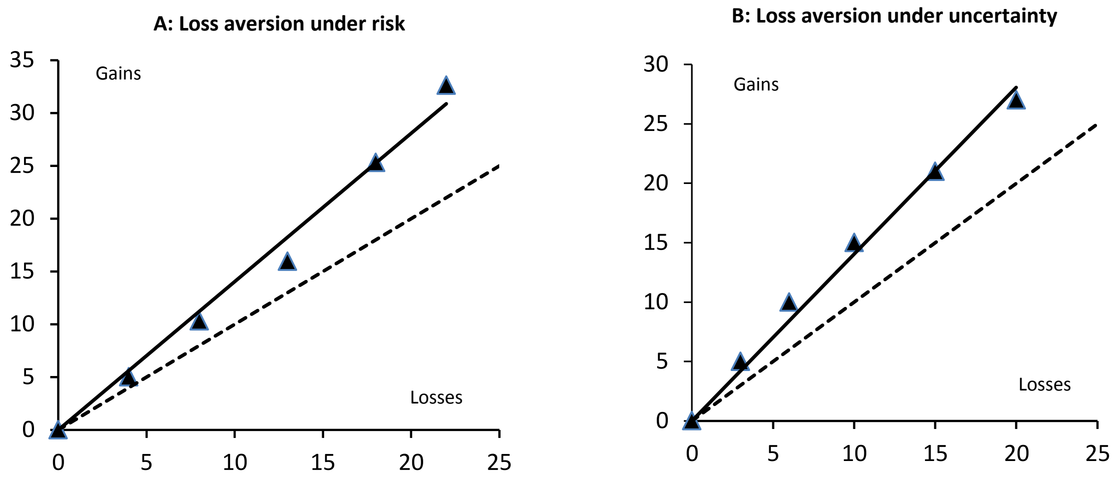


Figure 6: Median gains and losses with the same utility in absolute value. In panel A, the relationship between median gains and losses can be seen for the risk condition. Panel B shows the same relationship for uncertainty. The dashed line shows the case where the monetary gains and losses have the same absolute value in terms of utility.

In this method, the loss aversion that follows Kahneman & Tversky (1979) is implied by $x_j^+ > x_j^-$ (Abdellaoui et al., 2013). The finding that the $\beta > 1$ implies that $x_j^- < x_j^+$. A coefficient $\beta = 1$ would mean that the same gain or loss generates the same utility in absolute terms. Here, this is not the case and losses indeed loom larger than gains. However, this result is not as extreme as found by Abdellaoui et al. (2013), where they found $\beta = 2.32$ for risk and $\beta = 2.26$ for uncertainty. In spite of this difference, the coefficients found in this study are significantly different from one, indicating loss aversion. Additionally, the β coefficients for risk and uncertainty are indeed not significantly different. This would confirm the finding of Abdellaoui et al. (2013) that loss aversion is similar for risk and uncertainty. On the individual level, the results show that $x_j^+ > x_j^-$ for all j (all Wilcoxon test result in $P > 0.001$).

Table 4 shows the results under the two definitions of loss aversion by Kahneman & Tversky (1979) and Köbberling & Wakker (2005). From the table, we are able to see some loss aversion, as the both coefficients are significantly different from unity. However, the magnitude of the coefficients is less compared to the results of previous research for higher stakes. Kahneman & Tversky (1979) propose a coefficient of loss aversion of 2.25. Other research finds coefficients of loss aversion of similar magnitude or somewhat lower. e.g. (Abdellaoui et al., 2013).

Table 4: Results for the definitions of loss aversion by Kahneman and Tversky (1979) and Köbberling and Wakker (2005). The table show the median results for both risk and uncertainty. In addition, the table shows the interquartile range (IQR) for each definition of loss aversion for both conditions

	Median	Loss averse	Gain seeking	Loss Neutral
KT (1979) Risk	1,3192	84	31	5
IQR	1-2,078			
KT (1979) Uncertainty	1,4379	86	27	2
IQR	0,995-2,697			
KW(05) Risk	1,2375	79	21	22
IQR	1-1,875			
KW(05) Uncertainty	1,3333	87	21	14
IQR	1-2,632			

The results of correlations between the definitions show relatively high correlation between the definitions of loss aversion (Kendall's $\tau = 0.609$ for risk and $\tau = 0.711$ for uncertainty, both $P < 0.000$). In addition, the correlations for both definitions between risk and uncertainty are moderate (0.292 for risk and 0.311 for uncertainty, both $P < 0.000$). There are no significant differences between the two definitions of loss aversion for either risk or uncertainty (Wilcoxon test $P > 0.2703$).

7.5 Reflection

Reflection is a generally accepted feature of prospect theory that is widely researched and empirically observed (N. Barberis et al., 1999). The reflection effect implies that utility for losses is opposite to the utility for gains (Kahneman & Tversky, 1979), or a mirror image. This reflection effect is represented in the S-shaped function, where agents are risk averse for gains and risk seeking for losses (Kahneman & Tversky, 1979). The theoretical implication of reflection is that by studying one domain of the utility function, one might derive the behaviour of the function in the opposite domain, through the reflection effect (Abdellaoui et al., 2013). Further, reflection would imply that the psycophysical source of the response are similar for outcomes on the gain and loss domain (Abdellaoui et al., 2007).

The reflection effect was analysed by evaluating the power coefficients based on median data, as well as on the individual level. The results for the area measure show that there are no significant differences between the curvature for gains and losses for risk (Wilcoxon 0.7192) or uncertainty (Wilcoxon 0.5236). Similar results can be found by examining the power coefficients. Again, there are no significant differences between the power coefficients for gains vs. losses for risk (Wilcoxon 0.5182) or uncertainty (Wilcoxon 0.9341). The results replicate the findings of Abdellaoui et al. (2013) where they found that for the area measure and power coefficients there are no differences.

8 Discussion

Loss aversion is a widely regarded concept with no singular definition. The definitions most practical for this analysis were identified to be Kahneman & Tversky (1979) definition as well as the definition by Köbberling & Wakker (2005), in line with Abdellaoui et al. (2013). Under prospect theory, loss aversion is introduced as a general concept. However, the magnitude has been found less constant than originally proposed (e.g. Ert & Erev (2008)). For large stakes, loss aversion has been widely tested and verified (e.g. Abdellaoui et al. (2013)). For small stakes, the research is less thorough and this thesis is one of the first to utilize the method of eliciting utility for both gains and losses to form a full picture of the resulting function. In this thesis, the results include the finding that utility is reference-dependent and in general concave for gains and convex for losses, as shown in prospect theory (Kahneman & Tversky, 1979). Additionally, the results show loss aversion, even though the magnitude was less pronounced than in the research of Abdellaoui et al. (2013). Their research included high stakes, and it can be that subjects are on average less loss averse with the decreasing stakes. The thesis found that utility and loss aversion did not differ significantly between risk and uncertainty. This finding is in line with Abdellaoui et al. (2013) who find similar support for identical utility functions for risk and uncertainty.

The findings of this thesis show that loss aversion does exist for small stakes, but it may be less pronounced than previously stated. Kahneman & Tversky (1979) give a coefficient of loss aversion of 2.25, whereas this study returned results 1.34 and 1.44 based on median results for risk and uncertainty respectively. For the definition of Köbberling & Wakker (2005) the results were similar, with the coefficient of loss aversion for risk 1.24 and 1.33 for uncertainty. These results clearly show that loss aversion is lower for small stakes, in comparison to larger stakes. This would imply low stakes losses are perceived differently to high stakes losses. Abdellaoui et al. (2013) used a similar experimental procedure for larger stakes and obtained coefficients of loss aversion that were closer to the predictions of prospect theory.
The findings of this thesis corroborate the findings of Abdellaoui et al. (2013) that loss aversion is similar for risk and uncertainty. This result is especially interesting due to the mixed results that have previously been obtained (Geachter et al. 2007; Abdellaoui et al. Forthcoming). The findings are in line with utility being similar for risk and uncertainty.

The results present further support for prospect theory. The findings include convex utility for losses and concave utility for gains. The findings hold both at the aggregate and individual level. The power coefficient of $\alpha = 0.88$ seems reasonable, given the obtained results in this study. In addition, loss aversion was found on both aggregate and individual levels. Albeit, the degree of loss aversion was less than previous studies have found. This could be due to the size of the stakes involved in the experiment. If true, this would imply the variable nature of loss aversion to the choice task. The prediction of the reflection effect could not be substantially rejected. In addition, the subjects showed signs of ambiguity aversion which is in line with the empirical reseults of previous research, e.g. (Abdellaoui et al., 2013).

This thesis contributes to the existing research on prospect theory by using a parameter-free model that does not impose restrictive assumptions or force utility into a certain model. Additionally, the thesis extends the literature into loss aversion in small stakes, and shows that the degree of loss aversion can differ, if the magnitude of the losses is varied. This is in line with the findings by Ert & Erev (2008)and Ert & Erev (2013) who find that loss aversion is subject to magnitude effects. This thesis shows that the method developed by Abdellaoui et al. (2013) is highly usable for studying prospect theory and can be adapted according to the size of the stakes. The method is simple to use, and can be employed in laboratory settings involving multiple subjects per session. The method extends the trade-off method by Wakker & Deneffe (1996), illustrating the usability of the original measurement method.

A concern with the experimental design may be incentives. The sessions were of considerable length (between 30 and 60 minutes), and the task may be experienced as tedious. Some subjects mention that it requires effort to remain concentrated on experiment. However, the computer program was designed in a way that merely clicking at an alternative would not yield appropriate results, and it would not let the subject proceed. Using real incentives is difficult in an experiment where the subjects have the potential for losses. If real incentives were to be used, it may be possible if the respondents are given a show-up fee several weeks in advance. This may diminish the "house-money" effect and also help in recruiting subjects initially. If the experiment would have included real incentives, subjects may have had an incentive to inflate their preferences, in thinking they would receive a higher payoff.

The research on incentives provides alternative results that support using both real and hypothetical incentives. Using hypothetical choices is especially feasible for small stakes (Abdellaoui et al., 2013). This would imply that using real incentives would not produce results that are of large difference to the ones obtained here. The effect of incentives on behaviour is mixed. Camerer & Hogarth (1999) provide a review of this discussion. They find that incentives reduce variation in responses and help improve results for tasks where additional effort may increase performance. Further, Camerer & Hogarth (1999) mention that incentives may improve performance for clerical tasks, tasks associated with memory or recalling information. Opposing evidence is provided by Morgenstern et al. (2013) find that subjects exhibited more risk aversion in choices when faced with real incentives. Real incentives represent a cost to the research budget, and therefore to use real incentives, they should yield better results definitively. Here the effect of real incentives is unclear and research budget wise it may be smart to proceed with hypothetical incentives. To overcome this, future research could give an up-front show-up fee in advance, and then include the possibility of a small loss that does not exceed this amount. Now, the subjects received a flat-rate fee of EUR 10 after completing the experiment from one of the researchers.

In the experimental procedure, a disadvantage is the inability to control utility endpoints. This means that values may surge as subjects go through the choice tasks. A challenge related to the method stems from the sequential nature of the task. As subjects' previous choices influence the next ones, error propagation through the chained responses may occur. However, the effect of error propagation can be assumed to be minimal and do not influence the conclusions of the thesis (Bleichrodt & Pinto (2000))

9 Conclusion

This thesis concerned decision-making under risk and uncertainty for individuals under small stakes conditions. Economists often examine and model individual decision-making in the contexts known probabilities and unknown probabilities. The main goal of this thesis was to respond to the question "Does loss aversion exist for small stakes decisions?". The motivation for the topic comes from the literature. Prospect theory Kahneman & Tversky (1979) identifies loss aversion as a central feature and a stable construct. Other studies ((Harinck et al., 2007; Ert & Erev, 2008, 2013) find that loss aversion is less stable and is susceptible to magnitude effects and other destabilizing effects.

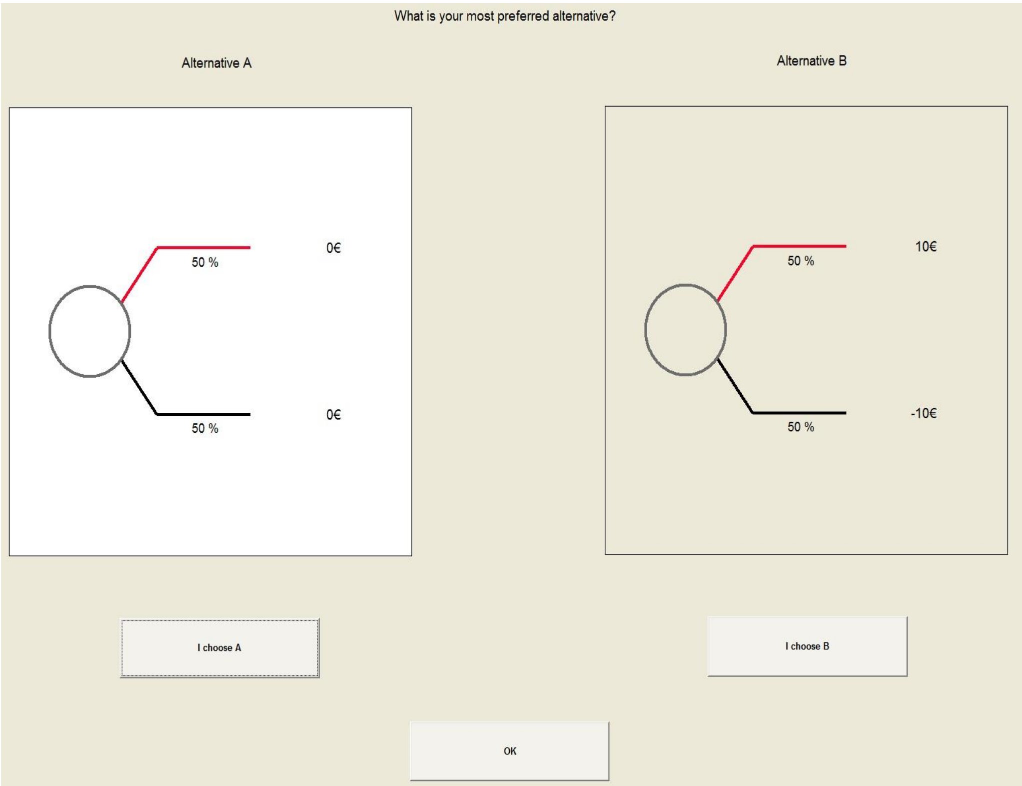
The previous literature has shown that loss aversion can be found in large stakes gambles by using a multitude of methods, including the non-parametric method used in this thesis (Abdellaoui et al., 2013). This thesis extended the literature into small stakes decisions using the non-parametric method developed by Abdellaoui et al. (2013). The main findings of this thesis confirm that utility is similar for risk and uncertainty, and that loss aversion exists for small stakes decisions. However, the magnitude of loss aversion found in the study was significantly less than predicted in prospect theory. The magnitudes found in this thesis were approximately 1.4, whereas prospect theory proposes a coefficient of loss aversion of 2.25 (Tversky & Kahneman, 1992). The second contribution of this thesis is to highlight the usability of the method of Abdellaoui et al. (2013), who extend the trade-off method by Wakker & Deneffe (1996) to elicit the full utility function over both gains and losses. The results of the experiment show evidence of the central features of prospect theory including ambiguity aversion, S-shaped utility, loss aversion as well as reference dependence.

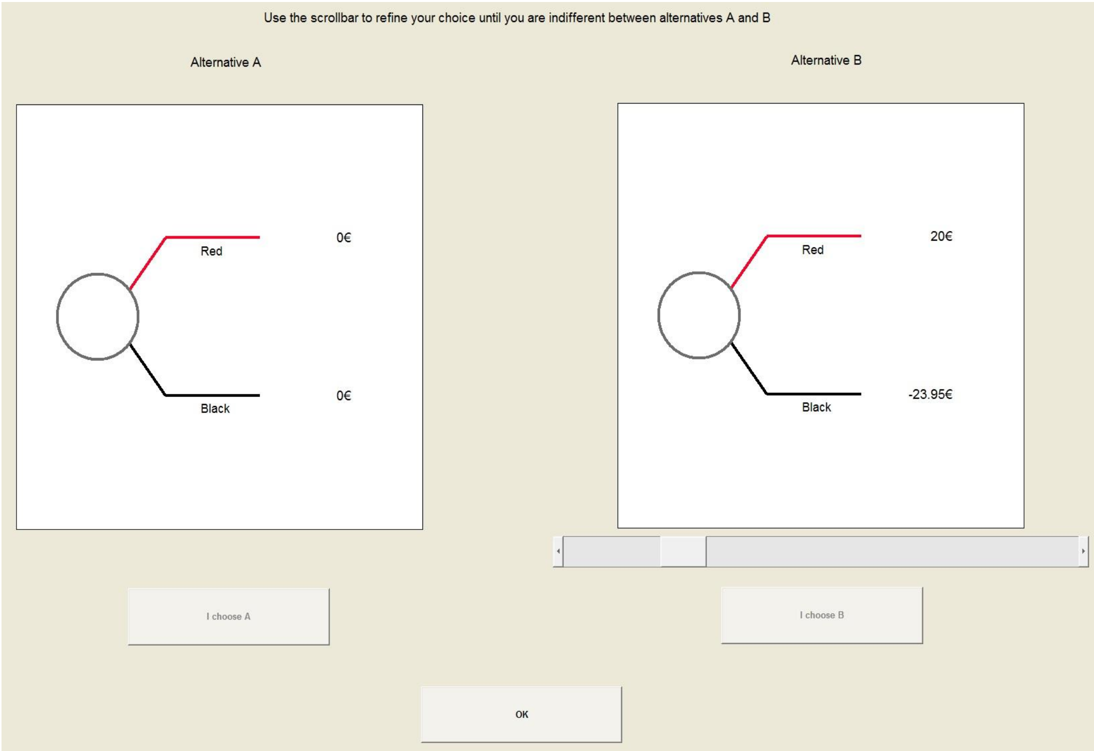
The results present a challenge to models relying on loss aversion being a stable construct. Magnitude effects seem to decrease loss aversion as found by Ert & Erev (2013). In addition, the results give more cause to revert from models whose assumptions rely on expected utility theory to hold. The experimental results imply that the utility of agents is reference-dependent and not concave throughout for both gains and losses. Implications of the results include the degree of loss aversion can be altered through the magnitude of the stakes. This could be used for benefit in a number of applications ranging from politics, investing, marketing and pricing. Loss aversion is clearly practically important in many areas, and understanding this feature of preferences may have benefits. Future research should pursue to gain a better understanding into the reasons and mechanisms behind loss aversion, and to form a unified definition for the phenomenon. In addition, future research should focus on better understanding the limits of loss aversion in its common definitions.

A Appendix

Details on the experiment and the screens used

	Subjects choices in Stage 1 for L	Subjects choices in Stage 1 for x_1^+
1	0 vs. (10:0.5 ; -10)	(10:0.5 ; 0) vs. 5
2	0 vs. (10:0.5 ; -5)	(10:0.5 ; 0) vs. 2.5
3	0 vs. (10:0.5; -7,5)	(10:0.5 ; 0) vs. 3.75
Scroll bar	Starting value: -6.25 Interval: [-10, -2.5]	Starting value: 3,125 Interval: [1.25, 5]




Use the scrollbar to refine your choice until you are indifferent between alternatives A and B
Alternative A
Alternative B
Red
0€
Black
0€
Red
20€
Black
-23.95€
I choose A
I choose B
OK

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