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Experiments on Time Preference and Risk Aversion

by

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ABSTRACT

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Many of the decisions we make as economic agents involve choices that play out over time and that involve outcomes that do not occur with certainty. This thesis explores these two dimensions of agent choice, time preference and risk aversion, using the tools of lab and online experiments. In the first chapter the thesis explores the impact of choice domain on agents' discounting and risk aversion by presenting subjects with choices over money and environmental outcomes in an incentivised lab experiment. It finds that while discounting behaviour remains unchanged, risk aversion increases when subjects make choices in the environmental domain. In the second chapter the thesis explores whether experimental incentives produce different results in the elicitation of time and risk preferences when compared to hypothetical experiments. Using a double-layered incentive mechanism it finds evidence that in discounting experiments in the environmental domain real incentives lead to increased patience as well as a decrease in the variance of responses. In monetary discounting we observe a significant increase in variance of incentivised responses compared to hypothetical ones. No such an effect is found in the risk aversion task. This suggests that the impact of incentives may be linked to familiarity and the cognitive load of the task being performed. In the third chapter the thesis explores the relationships between discounting *anomalies* by adapting a discrete choice experiment in order to elicit them simultaneously. It finds that the various *anomalies* are highly interacted, suggesting that their effect on utility is dependent on each other. This suggests that multi-attribute elicitation of such *anomalies* may provide further insight into their impact on discounting behaviour.

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Declaration of Authorship

I, Jana Sadeh, declare that the thesis entitled *Experiments on Time Preference and Risk Aversion* and the work presented in the thesis are both my own, and have been generated by me as the result of my own original research.

I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University;
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3. Where I have consulted the published work of others, this is always clearly attributed;
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6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
7. Parts of this work have been published as:
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Introduction

"My picture of the world is drawn in perspective. . . I apply my perspective not merely to space but also to time." Ramsey (1928)

Philosophers, psychologists and economists have all been equally fascinated by the topic of time. They have strived to understand how human beings make sense of time, how we internalise things that we expect to happen in the future, and how we make decisions when outcomes are distant from us in a temporal sense. They have linked the way we perceive the impact of time to behavioural traits such as patience and self-control. In turn these traits have been linked to higher educational achievement and increased social skills (Mischel et al. (1989); Frederick et al. (2002)).

1.1 The Role of Time and Risk Preferences in Choice and Social Policy

Intertemporal choices are an integral part of our everyday life. We are repeatedly making choices where the outcomes materialise in the future, or in a stream of future outcomes. These manifest themselves in complex decisions with many variables. Examples of monetary intertemporal choices include pension saving where current consumption is sacrificed in the hope of the enjoyment of a more comfortable retirement, consumption choices between more durable goods with longer lifetimes or cheaper more perishable goods, and spending more on a fuel efficient car in the expectation of savings on fuel in the future. Intertemporal choices also dominate decisions in other, non-monetary, aspects of our lives. This includes health choices which involve a tradeoff between consuming sugary goods today and maintaining a healthy body weight in the future, or getting vaccinated in order to reduce the chance of needing medical treatment in the future. Time is also central to most of the big environmental challenges of our day. It can be felt in environmental choices such as choosing energy saving appliances or insulating one's house in expectation of energy savings in the future, as well as public good choices of recycling or planting pollinator-friendly plants in the garden in order to contribute to improved environmental outcomes in the future. It can also be felt in bigger picture decisions such as the choice of investing in renewable energy today and decreasing the reliance on carbon in the future, or sacrificing fish catch numbers today to ensure the preservation of fish stocks in the future. It is clear that intertemporal choices permeate our society and our everyday life and can be central to the quality of life people enjoy now and in the future. However, research has shown that people are notoriously bad at making intertemporal decisions. They are highly myopic (Soman et al. (2005)) and unable to clearly internalise the benefit they will receive in the future in a way that allows them to make decisions that are objectively in their best interest. The degree to which people fail to account for their future selves has led to serious debate at the policy level, with governments concerned that people are not acting in their own best interest. The severe under-investment in pensions as a clear example of this.

The level of under-saving in pensions has led the British government to intervene and *nudge* people into behaviour that is more beneficial for themselves by making pension saving an opt-out process rather than an opt-in one in order to capitalise on the inertia people have about taking action on pension saving.

To further blur to the image we have of our future selves, real world intertemporal decisions are not a simple trade-off between two known outcomes with a time delay. It is often the case that as time becomes more distant, so does the certainty we can attribute to given outcomes. Our lives are also permeated by decisions where the outcomes of those decisions are uncertain. Examples abound of monetary gambles, choice of treatment options for medical conditions, and the level of CO_2 emissions we are willing to tolerate. The outcomes of these actions are not known with certainty. One could ask themselves: Why should I save if I am not sure I will live to see retirement? Why should I reduce my carbon emissions if there is a chance that we've got the figures wrong, or that new technology will be invented that will take care of the problem for us? Our perception of risk, our understanding of risk and our attitudes towards risk therefore form a vital part of our intertemporal decision making process. Without our explicit knowledge we are taking account of perceived probabilities of future outcomes when making intertemporal decisions. In fact we are processing a highly complex formula in every intertemporal decision we make.

Understanding intertemporal decisions is vital for the understanding of how economic agents make decisions. In addition, it is clear that intertemporal decisions are intertwined with risky decision making and the two are complementary in the understanding of this process and a meaningful investigation of one requires the investigation of the other (Andersen et al. (2008); Gattig and Hendrickx (2007)). Understanding of how economic agents make intertemporal and risk tradeoffs, and what factors influence them in this process, is essential for policy makers attempting to address issues of sustainability of pensions, obesity, addiction and, the core focus of this paper, for the understanding of environmental sustainability.

In addition to our understanding of the mechanics driving decision making, the rate

of time preference and risk aversion are the key components of policy discount rates used by the governments of many countries, including the United Kingdom, to evaluate the costs and benefits of investment projects. As an example, the Department for Environment, Food and Rural Affairs (DEFRA) in the UK uses a policy discount rate of 3.5% (HMTreasury (2018)) which is comprised of a time preference element and a risk element. Discount rates in a cost-benefit analysis are applied as a weight to decrease the value of streams of positive outcomes occuring in the future. The higher the discount rate used, the higher the penalty applied to benefits which will be generated by the environmental project throughout its lifetime. Our collective knowledge of these parameters have the potential to transform such policy parameters and as a consequence have real world impact on environmental projects getting the support of public funds.

This thesis touches upon a number of important aspects related to time and risk preference. One theme running through the three papers presented in this document is that of domain. Domain refers to the realm in which the decision making is taking place, in other words it refers to the context and good being evaluated. Domain research investigates whether the way we perceive time and risk depends on the type of outcome being considered. This would imply that when thinking of money we have different time and risk perception than we have when thinking of our health or the environment. Environmental practitioners are, rightly, concerned about the application to environmental policy of tools designed for monetary markets. The criticism is that one cannot simply take conclusions derived from monetary markets and apply them to a market that is structurally, and perhaps, morally, so distinct as the environmental market. This thesis investigates the possible distinction between the two in the eyes of economic agents. For the first time an incentivised laboratory experiment is used to test the hypothesis that time and risk preferences are domain dependent, or differ according to domain. Domain is only one of many dimensions of intertemporal and risk preferences, this research will go on to involve other such dimensions.

A second theme involves a methodological issue of elicitation method. There are numerous ways in which we ask subjects to reveal their time and risk perferences; different physical set ups, online or lab based experiments, different incentives we use

to encourage participation and truthful revelation of preferences, and indeed different tasks that can be used to determine such preferences. This thesis attempts to answer some questions about how researchers elicit time and risk preferences, in particular on the use of real incentives (as opposed to hypothetical experiments) by comparing, for the first time, the responses to incentivised and hypothetical experiments on environmental discounting and risk aversion. It also looks into the simultaneous elicitation of multiple anomalies by using discrete choice experiments as an alternative elicitation method.

It is important to highlight, before we delve into the deeper analysis of time and risk preferences, that this thesis is purposefully ambivalent on the debate surrounding the choice of discount rate to be used in policy evaluation. This discussion is more suited to an ethical and political analysis of the topic rather than an economic one. The implications of using discount rates on issues of inter-generational equity and on existential risks associated with environmental outcomes are important issues that deserve addressing in a complete way. The objective of this thesis is rather to discuss the descriptive aspect of time and risk behaviour, which involves examining how people make decisions in these areas.

Economists have always been interested in how individuals make decisions with outcomes that play out over time and uncertain states of nature. The two conflicting needs of our discipline, accuracy and parsimony, are brought into the spotlight when it comes to the topics of discounting and risk aversion. The models that have been at the forefront of these areas score highly on parsimony but struggle with the accuracy. The observed decisions contrast strongly with the *a priori* expectations borne out of these models and have spurred a vast literature on a number of so-called *anomalies* of behavior. The most recent work on understanding the motivations behind the observed decisions, in order to improve accuracy, struggles to reach a harmonious consensus. The following paragraphs provide an overview of the fundamental discounting and risk models and the *anomalies* that result from violations of the models.

1.2 Discounting Literature

From the first attempt to bring the topic of intertemporal choice to the fore by Rae (1834) to the current debates over functional forms of discounting models, the topic of discounting has accumulated a substantial body of literature.[1] The following paragraphs outline the Discounted Utility (DU) model and the *anomalies* that arise out of the implied assumptions. They continue on to explore the role of risk aversion within discounting and the similarities between the DU model and the Expected Utility (EU) model and the two bodies of literature that emerge out of these models.

The Discounted Utility (DU) model proposed by Samuelson (1937) was the culmination of the historical philosophical thinking about intertemporal choice. This work attracted considerable interest and eventually became the standard model for the incorporation of time in economic models. The reason for this had little to do with its ability to describe the intricacies of intertemporal choices made by economic agents.

As Frederick et al. (2002, p352-3) explain, *"when the DU model eventually became entrenched as the dominant theoretical framework for modeling intertemporal choice, it was due largely to its simplicity and its resemblance to the familiar compound interest formula, and not as a result of empirical research demonstrating its validity"*. In fact, as we will outline in the following paragraphs, this model has been shown to require too many simplifying behavioral assumptions to adequately model observed intertemporal choices of agents. The discord between economic theory and observed choices fueled interest in understanding the determinants of agents' intertemporal decisions. Much of the current literature is devoted to documenting the deviations (*anomalies*) in the behavior of agents from the predictions of the DU model.

[1] For a full exposition on the history and literature on discounting see Frederick et al. (2002).

1.2.1 The Discounted Utility Model

The formalisation of discounting in mainstream economic theory was the work of Samuelson (1937) who introduced the Discounted Utility (DU) Model. The DU model specifies the intertemporal preferences of an economic agent over consumption profiles over time. The model makes the usual assumptions on utility of completeness, transitivity and continuity. Preferences are represented by the intertemporal utility function (U^t) below.

$$U^t(c_t, ..., c_T) = \sum_{k=0}^{T-t} [\tfrac{1}{1+\rho}]^k u(c_{t+k})$$

Where $u(c_{t+k})$ is the cardinal instantaneous utility function, ρ is the discount rate and k is the time difference between the current time (t) and a future time period that is being evaluated. This implies that $[\frac{1}{1+\rho}]^k$ is the discount function that conveys the weight at time t attached to the utility of an outcome occurring at time $t + k$.

In this model of intertemporal choice all the factors motivating a preference for present day consumption over the postponement of such consumption can be condensed into one parameter called the discount rate (ρ). This simplicity is one of the strengths of the model, however it is also its largest weakness. The inability of ρ to fully explain the disparate behavior that is observed in intertemporal choice has motivated the literature on the *anomalies* that are born of this model. Samuelson understood that the model he proposed was overly simplistic. He did not intend it to be a normative model of intertemporal choice, i.e. a model that describes how individuals *should* be making decisions, nor did he believe that it was an accurate descriptive model which fairly depicted the behavior of agents (Samuelson (1937); Frederick et al. (2002)). Despite his intentions, this is what the DU model has become in modern economics.

1.2.2 *Anomalies* and the Domain Effect

The consequence of the parsimony of the DU model is the number of assumptions that are being implicitly made by the model. These have been found to be weak descrip-

tors of observed intertemporal choices of individuals. The failures of the DU model to explain observed behavior are referred to as *anomalies of discounting*. They are not anomalies in the sense that they are seen as errors made by people, as they do not violate any rules that we can plausibly expect them to observe, rather, they are anomalous to the DU model. The consensus that emerges from the literature is that it is the DU model that is unable to adequately model real world intertemporal preferences (Frederick et al. (2002)). Other models have been put forward to improve the predictive ability of the discounting model, however no one model has yet triumphed as the replacement for the DU model.[2]

The implicit assumptions made by this one-parameter model suggest that individuals are characterised by one constant rate of time preference (*constant discounting*) and that this rate does not change based upon previous consumption (*consumption independence*) or the time in which such choices are made (*stationary instantaneous utility*). Intertemporal decisions are evaluated within the context of the individual's current consumption (*integration of new alternatives*) and that individuals have no preferences for increasing/decreasing utility over time (*utility independence*).

Another implicit assumption of the DU model is the assumption of *independence of discounting from consumption*. This suggests that the discount rate is invariant across all forms of consumption. This would mean that individuals discount money, consumption goods, health outcomes and environmental outcomes in the same exact way. This is the assumption that is of primary relevance to the research undertaken in this paper.

A substantial portion of the literature on intertemporal preferences is devoted to documenting diversions from these assumptions, which has resulted in a strong body of research on the so called *anomalies* of discounting. Researchers noticed that when presenting subjects with choices between a smaller outcome to be received sooner and a larger outcome to be received later in time, longer time delays yielded lower discount rates than those obtained from shorter delays (*delay effect*) (Thaler (1981); Chapman

[2]For an overview of the alternative models of intertemporal choice in the literature see Doyle (2013) and Frederick et al. (2002).

(1996b)) in contrast with the theoretical prediction of the DU model. They also noticed that the time intervals, which the delay between the smaller sooner and larger later outcomes are split into, also impacts the discount rate elicited. The discount rate elicited for a long delay is smaller than the discount rate for the same delay broken into two smaller delay intervals (*interval effect*) (Read (2003)). These two effects have been attributed as the cause of the intertemporal behaviour which has given rise to the literature on *hyperbolic discounting* (Frederick et al. (2002); Read (2003)). In addition, there is evidence that small outcomes are discounted more than large ones (*magnitude effect*) (Prelec and Loewenstein (1991); Loewenstein and Prelec (1992); Chapman (1996b); Chapman and Winquist (1998)), discounting is larger for delaying an improvement than for expediting it (*direction effect*) (Loewenstein (1988)), and gains are discounted more than losses (*sign effect*) (Thaler (1981); Shelley (1993)).[3]

The assumption of the independence of discounting from consumption implies that the discount rate elicited should be independent of the decision domain that is being evaluated. This is violated when we observe discount rates that vary depending on the outcome that is being evaluated. This *anomaly* undermines the idea that agents are characterised by a unitary discount rate. Rather it suggests that an individual's rate of time preference varies depending on the nature of the good they are evaluating (Frederick (2005)). This is the domain dependency of discount rates (*domain effect*) and implies that the mean discount rate in one domain may be different to that of another.

In the literature, *domain* is interpreted to encompass a range of related outcomes. The literature on domain differences has mainly centered around the health domain (Chapman (1996b, 2003); Cairns and van der Pol (1999)) but has recently expanded to include the environmental domain (Hardisty and Weber (2009)). Our contribution to the literature stems from providing, to the best of our knowledge, the first study that uses real, incentivized discounting and risk choices in both the monetary domain and the environmental domain. The term *health domain* is used when discussing outcomes such as improvements in quality of life, reduction in sick days and treatments to improve ailments. The term *environmental domain* is used to capture outcomes such as water

[3]For a detailed exposition of the above effects please see Frederick et al. (2002) and Read (2003).

and air quality improvements, improved waste management and reductions in traffic congestion. In their research on the health domain, Tsukayama and Duckworth (2010) confirm the application of the term to encompass a large number of items that share similar properties and are evaluated using similar criteria.

1.3 Risk Literature

Utility is a three dimensional construct, with time and risk preferences representing two of the three dimensions and the outcome (goods) being the third (Andersen et al. (2008)). Risk and time preferences are distinct constructs that are intertwined (Andreoni and Sprenger (2012)). The utility function describes preferences for outcomes defined by a time period and a state of nature. It also defines preferences over the temporal allocation of outcomes as well as defining preferences over outcomes as realizations of uncertain states of nature. This close relationship has meant that discounting experiments must account for the impact of risk on time preferences (Andersen et al. (2008)).

The Expected Utility (EU) Model is seen as the parallel of the DU model with the difference that in the EU model the decision maker chooses between different alternatives that occur at the same time but whose outcomes do not occur with certainty (Prelec and Loewenstein (1991)). Like the DU model it is a model that has been used both as a descriptive and a normative model of choice due to its simplicity and its similarity to the financial formulas already in use (Prelec and Loewenstein (1991)).

The EU model was given a more formal axiomatic background by Von Neumann and Morgenstern (1953) in a similar fashion as was done for the DU model by Koopmans (1960) and again in the same spirit research has focused on a number of ways that individuals *violate* the model by uncovering behavioural *anomalies*. The parallels between the DU and EU models reflect the fundamental properties that are shared by both models (Prelec and Loewenstein (1991)).

1.3.1 The Expected Utility Model

In a parallel fashion to the DU model, the incorporation of risk into utility functions has been developed using the Expected Utility (EU) model. In this model preferences over outcomes are weighted by probabilities associated with the different outcomes in a similar way that the DU model is weighted by a discount factor that attaches a smaller weight to outcomes in the future (Prelec and Loewenstein (1991)). Preferences are embodied by a utility function that may take on a non-linear form, while the preferences over the probabilities associated with the various outcomes are linear (Wibbenmeyer et al. (2013)). The EU model was developed by Von Neumann and Morgenstern (1953) who set out the axiomatic structure that explains the logic behind the model and the implicit assumptions that .

Preferences are represented by the expected utility function (EU) below.

$$EU(c_i, ..., c_N, p_i) = \sum_i^N f(p_i)u(c_i)$$

Where $u(c_i)$ is the risk-free utility associated with the consumption of outcome i and $f(p_i)$ is a function that assigns non-negative probabilities to the different possible outcomes c_i'.

1.3.2 *Anomalies* and the Domain Effect in Risk

The relationship between these two dimensions extends to include the observation of the same *anomalies* of choice. *Anomalies* that have been observed in intertemporal literature, such as the magnitude effect and the sign effect, are also mirrored in the risk literature. Prelec and Loewenstein (1991) outline the parallels between the *anomalies* in risky and intertemporal choice when it comes to the magnitude effect. This effect describes the decreasing risk aversion with decreasing monetary amounts and has been christened as the *"peanuts effect"* (Prelec and Loewenstein (1991); Weber and Chapman (2005)). Subjects are found to be less risk-averse for small gain than for larger ones (Green et al. (1999)). A number of other *anomalies* have been documented. The

common ratio / common difference effect has been reported (Kahneman and Tversky (1979); Prelec and Loewenstein (1991)), where the multiplication of the risky outcomes by a common factor induces a change in preferences that are incongruous to the EU model. Certainty effects refer to the discontinuity that occurs at a probability level that is close to certainty (a p close to 1) where outcomes that are almost certain are valued disproportionately and a small change from certainty to almost certainty incurs a large penalty in terms of utility (Kahneman and Tversky (1979)). Sign effects present the case where risk preferences switch from risk averse to risk seeing when the payoffs have a change in sign to switch from positive to negative outcomes (Kahneman and Tversky (1979)).

The similarities between intertemporal and risk preferences extend to the existence of domain differences in risk. The effect of the choice domain on the risk preferences elicited has been documented by Weber et al. (2002) who note that individuals are not characterised by one risk attitude, but rather exhibit different levels of risk preferences depending on the domain. Riddel (2012) finds that subjects overemphasise low probability, extreme environmental outcomes more than financial ones.

Studies have historically presented subjects with hypothetical environmental outcomes when outlining intertemporal tradeoffs. Böhm and Pfister (2005) used hypothetical scenarios on coastal erosion and marine oil spills, and Viscusi et al. (2008) used improvements in water quality. Hardisty and Weber (2009) used hypothetical scenarios on air quality improvements and losses, mass transit gains and garbage pile-ups to capture the environmental domain.

The belief held by many experimental economists is that the use of real payoffs creates a strong incentive for subjects to display their true preferences and increases the attention given to the task at hand. These are examined in further detail in the next subsection.

1.4 The Effect of Incentives on Risky Choices

There is a large body of literature dedicated to understanding the impact of monetary incentives on the outcome of risk tasks performed by subjects in laboratory experiments. Since risk aversion and discounting tasks measure preferences rather than performance, there is no way of assessing whether incentives improve performance other than to monitor differences between the two treatments or any deviation from an *a priori* expectations of economic theory. The findings from these studies are mixed. Beattie and Loomes (1997) find no effect of incentives on risk aversion, while Grether and Plott (1979) and Edwards (1953) find evidence of more risk-seeking behavior in real gambles. Battalio et al. (1990); Binswanger (1980); Hogarth and Einhorn (1990); Holt and Laury (2002) find the opposite effect, that subjects are more risk averse when presented with a real incentivized choice of gambles and Cubitt et al. (1998) only find evidence of increased risk aversion for complex multi-stage gambles.

Authors reviewing experimental comparisons of the effects of real payoffs, such as Camerer and Hogarth (1999), conclude that impact of real payoffs is less clear cut than economists would like to think. Camerer and Hogarth (1999) review 74 experiments comparing different levels of financial incentives and find no effect of financial incentives on mean performance. They do note a reduction in variance and a reduction in presentation effects. Their conclusion is supported by the mixed evidence on the matter that is found in the literature.

The debate of the effect of payoffs on elicited risk preferences is confounded by the fact that three methods of payment are used in such tasks. The first is a purely hypothetical set up where the payoffs received at the end of the experiment are unrelated to the subject's choices in the risk tasks. The second is a fully paid experiment where subjects make one gamble choice and the outcome of the gamble is paid out in real money. The third, and most popular, method used by experimenters is the random-lottery payment, where subjects perform a number of risk tasks and one of these is selected for payment at the end of the experiment. Tests on the impact of real payoffs (versus hypothetical ones) have been carried out with both the one-game paid set up as

well as the random lottery set up. Only one experiment, that we are aware of, directly compares all three methods (Beattie and Loomes (1997)).

Experimenters are divided about the differences between random-lottery and real payoffs. The arguments presented against the equality of fully paid real experiments and random-lottery experiments fall broadly into two camps; the first argues that payoffs are such a strong motivator of subject behavior that random-lottery payoffs lead subjects to take the harder path of analysing the entire experiment in a more complex manner as they attempt to maximise such payoffs (*the reduction hypothesis*) (Cubitt et al. (1998)); while the second centers around the fact that the salience of payoffs is reduced when random-lottery payoffs are used as subjects factor the probability weighting into the evaluation of the payoff and this dilutes their impact (Beattie and Loomes (1997)). The first argument has been rebutted by a number of authors (Hey and Lee (2005); Hey and Zhou (2013); Cubitt et al. (1998)) who show that subjects do, in fact, treat each question in a random-lottery experiment separately rather than as one large question and that they treat each one as though it were going to be the one that would be selected for payment. The second argument, that suggests that the use of random-lottery dilutes the impact of payoffs is one that finds some (mixed) support in literature. Proponents like Harrison (1994) support such an argument, however others (Starmer and Sugden (1991)) find no evidence of any difference between the random-lottery and fully incentivised experiments.

In an experiment that directly investigates the effect of different payoff structures on choices on gambles by comparing three treatments, a fully hypothetical experiment, a random-lottery (or random problem selection procedure) experiment and a fully paid experiment, Beattie and Loomes (1997) find no evidence that there is any treatment effect in three of four gambles presented to subjects. The one gamble where the three treatments exhibit a significant difference has the unique characteristic of being a multi-stage gamble that requires a stronger cognitive effort on the part of subjects and requires them to internalise future scenarios, suggesting that the impact of incentives is task-specific. In pairwise comparisons of this particular game, the authors find a significant effect between real and hypothetical, a weaker effect between real and random-lottery

and no effect between random-lottery and hypothetical.

Davis and Holt (1993) argue that while the evidence for the effect of payoffs might not be significant, there is evidence that random-lottery has a diluting effect on the impact of real payoffs. The idea that the three alternative methods for payment lie on a scale of impact seems to be the take-home message from this work. Camerer (1995) agrees that the effect of payments on subjects is task specific. In the case of decisions under risk and uncertainty he concludes that when real payoffs are used in tasks that involve choices over gambles there is no improvement in the behavior of subjects that brings them closer to *a priori* expectations based on axioms of rationality. Cubitt et al. (1998) agree that the effect of payoffs is not significant for simple tasks but may become more relevant for more complex ones.

1.4.1 Hypothetical Bias in Valuation

Requiring subjects to make intertemporal decisions requires them to understand what value they will attach to an outcome at a point in the future and compare that to the value they attach to the same outcome in the present (or nearer future). There is a vast literature on the difficulties that people find in expressing such hypothetical valuations in areas such as environmental and health valuations of willingness to pay. In this literature the difference between hypothetical and actual expressions of value is called *hypothetical bias*, where comparisons are often made with actual valuations are obtained from experiments with real economic commitments (List and Gallet (2001)).

The literature on this area started with the seminal work by Bohm (1972) and gained momentum in the last decades where numerous studies have looked into whether such a bias exists and whether we can account for it when conducting valuation studies. While there is some evidence of cases where hypothetical and actual valuations were identical (Mentzakis and Mestelman (2013); Smith and Mansfield (1998); Johannesson (1997)) most studies found that hypothetical valuations exceed actual values (List and Shogren (1998); Fox et al. (1998); Cummings et al. (1995)). In a meta analysis conducted by List

and Gallet (2001) which analysed 29 experimental studies, hypothetical valuations were larger than actual ones by a factor of 3. Murphy et al. (2005) confirm these findings in their own meta analysis of 28 stated preference valuation studies and find a mean calibration factor of 2.60. Harrison and Rutström (2008) also support the existence of hypothetical bias and shift the focus on attempting to understand which situations magnify this bias and to some extent, its underlying cause.

Cummings et al. (1995) find that the presence of hypothetical bias is robust to different private goods (juicer, chocolate and calculators), to different geographic settings, to different experimenters, to different questionnaire formats and to the use of non-students. In their attempt to understand the main determinants of the difference between the hypothetical and real valuations List and Gallet (2001) found a significant impact of whether the subject was asked for their willingness to pay or willingness to accept, whether the good was a private or public good and the type of elicitation method used. List and Gallet (2001) allude to the fact that these elements point to the concept of the *familiarity* of subjects with the question being posed as the underlying determinant of the differences between hypothetical and real valuations - which are perceived as *errors* made by subjects in conveying their true value.

Johannesson (1997) adds a question testing subjects' confidence in their valuation, asking them whether they were sure they would buy the good. His findings, that this question removes evidence of hypothetical bias, further supports the theory that it is an issue of unfamiliarity and uncertainty in the valuation exercise that drives the diversion of real and hypothetical values elicited. This same familiarity is cited by Harrison and Rutström (2008) as the possible reason behind Smith and Mansfield (1998)'s lack of evidence of hypothetical bias.

1.4.2 Effect of Incentives in Discounting

The literature on the presence of a payoff effect in discounting experiments is less populated. There is evidence that the use of real payoffs matters in discounting experi-

ments. Kirby and Marakovi (1995) find that discount rates elicited for real monetary payoffs were higher than those for hypothetical ones. Testing a similar setting Coller and Williams (1999) are less conclusive in their findings while, in a wide survey on the role of real incentives, Camerer and Hogarth (1999) find no effect on mean performance but they find a reduction in variance with high financial incentives, and note that high incentives improve performance in demanding tasks and reduce presentation effects.[4] The effect of incentives is also confirmed by other studies investigating the impact of using real payoffs in experiments (Kroll et al. (1988); Cummings et al. (1995)). There is no literature on payoff effects in environmental discounting tasks, this will be the first experiment to test for such a an effect.

Given the similarities in the two strands of literature presented above, of payoff effects in risk aversion and hypothetical bias in valuation, the findings in these areas can be used to better inform our knowledge on the potential impact of incentives on environmental discounting and risk aversion.

1.5 The Experimental Approach

Experimental economics may seem like a relatively recent addition to the field of economics, with Vernon Smith receiving the Nobel Prize for his work in advancing this field in 2002, however it began as early as 1959 with the publication of the first of many papers and books on the topic. The use of laboratory experiments in the field of economics was a groundbreaking one at the time, and is still met with a degree of skepticism by some. Today, however, the papers that had originally started with a narrow focus on market efficiency have expanded to include research on many areas, and experimental economics has become an important element of the toolkit economists use in order to further their quest for knowledge.

Experiments attempt to study behaviour of individuals and groups who are motivated

[4] In their research the presentation effects that were referred to were generosity and risk-seeking behavior.

to perform specifically designed tasks in computer laboratory settings. The aim of using experiments is manifold, they can serve as a test for economic theory before collecting data from the field, they can be used to deepen our understanding of data already collected from the field. They allow us to create environments that are not suitably available for observation in the real world and allow us to isolate variables that would be hard to distinguish in real markets. The characteristics of behaviour that individuals exhibit in the real world, which form part of the underlying assumptions that economists make (self-interest, interdependent tastes, risk aversion, subjective transactions costs, costly information etc.), also manifest in laboratory experiments (Smith (1991)). Experiments are especially useful in allowing economists to test these behavioural assumptions and to use experimental results for modification of the original model.

This thesis presents findings from a lab experiment carried out at the University of Southampton that was comprised of two parts, an incentivised version which feeds into Chapter 2 and a hypothetical version which feeds into Chapter 3. In addition the thesis presents the findings from an online experiment which feeds into Chapter 4. The benefits of online experiments are the greatly reduced cost and convenience, as well as the ability to reach a wider sample than the traditional reach of undergraduates on campus that are recruited for lab based experiments. It allows for some sampling stratification and for repeated interaction with participants if necessary. The popularity of online experiments is growing proportionally to the ease of access to subject pools and developments in technology which have greatly increased the ease of carrying out such experiments. Horton et al. (2011) find that online experiments are able to achieve the same external validity as traditional experiments and believe that the field of economics would benefit from the integration of such efforts in an "online laboratory" to allow more researchers to make use of this tool. This technology has been advancing in recent years and these advances have facilitated the use of online experimental methodology in this thesis.

1.6 Research Questions

This thesis attempts to shed light on the following three research questions:

Q1. Do individuals evaluate delayed and risky monetary outcomes in the same way that they evaluate delayed and risky environmental outcomes?

Q2. Do the discount rates and risk aversion parameters obtained from hypothetical experiments on money and environmental goods differ from those obtained from incentivised experiments?

Q3. Do *anomalies* impact discounting decisions in an individual/direct way or an interacted manner?

1.7 Overview of Findings

The first paper, looking at whether choices about money differed from choices about an environmental good, finds evidence of a domain effect in risk aversion. It identifies that individuals appear to be more risk averse when playing with environmental goods. It finds no such effect for discounting choices. The results from the second experiment, comparing incentivised and hypothetical settings, finds that incentives impact the mean and variance of responses given for tasks that require higher cognitive effort such as discounting. It finds no such effect on risk aversion choices. The third experiment shows that it is possible to model simultaneously multiple *anomalies* using a discrete choice experiment set up. It finds that these *anomalies* interact strongly with each other in their impact on utility. This implies that the effect of an individual *anomaly* is not consistent across all other dimensions of time preference, and that research needs to incorporate multiple *anomalies* in a multi-attribute environment in order to properly reflect the discounting process.

1.8 Contribution

The first paper on tests on domain difference for time preference and risk aversion has been co-authored with Christos Ioannou (University of Southampton). My contribution to this paper was to come up with the initial idea. The experiment was jointly designed. I was responsible for carrying out the data collection and analysis and contributed to writing the manuscript. The second paper on the effect of incentives in time and risk preference was co-authored with Emmanouil Mentzakis (University of Southampton). My contribution to this paper was to come up with the initial idea and design the experiment. I was also responsible for carrying out the data collection. I contributed to the data analysis and writing the manuscript. The third paper has been a joint effort with Emmanouil Mentzakis (University of Southampton). I contributed to the idea generation for the paper. The experiment was jointly designed. I was responsible for carrying out the data collection and analysis and wrote the manuscript.

1.9 Thesis Structure

The following chapters contain the three research papers undertaken for this PhD. The first of which is the investigation into the role of the environmental domain in time and risk preferences. The second presents the analysis of the impact of real incentives in a lab experiment setting on the elicited time and risk preferences and tests whether the use of incentivised experiments impacts the responses given by subjects to environmental discounting and risk tasks. The final paper looks into the multi attribute elicitation of discount rates and the revealed interactions of the anomalies presented. It takes a more holistic approach to discounting using a multi-attribute elicitation technique that enables the elicitation of multiple anomalies simultaneously using discrete choice experiments and places time delay as only one of a number of changing characteristics. The dissertation concludes with a section that draws upon the results obtained in the papers to look forward into what lies ahead for research on time and risk preferences.

2

Domain Differences in Time and Risk Preferences

2.1 Introduction

The design and evaluation of environmental policy requires the incorporation of time and risk elements as many environmental outcomes extend over long time periods and involve a large degree of uncertainty. Understanding how individuals discount and evaluate risks with respect to environmental outcomes is a prime component in designing effective environmental policy to address issues of environmental sustainability, such as climate change. Our objective in this study is to investigate whether subjects' time preferences and risk aversion across the monetary domain and the environmental domain differ.

We elicit subjects' time preferences and risk aversion using a controlled 'within-subject' experimental design (Charness et al. (2012)). First, to isolate the effect of domain on intertemporal choices, we use the fixed-sequence choice titration (Harrison

and Lau (2005); Read et al. (2005); Andersen et al. (2008); Hardisty and Weber (2009)). In this approach, subjects are presented with a series of binary intertemporal choices between a fixed amount that is due at one point in time (henceforth referred to as *smaller sooner*) and a larger amount that is due at a later point in time (henceforth referred to as *larger later*). While the smaller sooner amount is kept fixed, the larger later amount increases successively. In the beginning, subjects typically prefer the smaller sooner amount to the larger later one. However, at some point, a switch takes place from the smaller sooner to the larger later amount, which enables the experimenter to extract the discount-rate bracket within which the individual's rate of time preference lies. Second, to elicit subjects' risk aversion, we use a variant of the Eckel-Grossman test (Eckel and Grossman (2002); Eckel and Grossman (2008)), where subjects are presented with five gambles of varying riskiness and are required to select the one they prefer. Crucially, in order to ensure that the magnitude of the choices in the monetary domain matched those in the environmental domain, prior to running the experimental sessions, we calibrated the value of the environmental instrument using two contingent valuation studies. Finally, we use the Cognitive Reflection Test (Frederick (2005)) and a questionnaire to obtain both a measure of subjects' cognitive ability to reflect and deliberate in the face of intuitively simple alternatives as well as insights to subjects' environmental attitudes, which could possibly relate to the way different domains are evaluated.

A novelty of the experimental design is that it is incentivized: in the monetary domain, time preferences and risk aversion are elicited with real monetary payoffs, whereas in the environmental domain, we elicit time preferences and risk aversion using real (bee-friendly) plants. These were presented as a public good, the participants were told that the plants would be distributed, without charge, to staff and students at the University of Southampton while in bloom and that they would provide an immediate benefit to bee populations by providing them with needed nectar. This distribution was indeed carried out. The value to participants would stem from the indirect use and existence values. [1] [2]

[1] There exists evidence to suggest that incentivized experiments may have an impact on the discount rates elicited (Coller and Williams (1999); Kirby and Marakovi (1995); Andersen et al. (2014)).

[2] To the best of our knowledge, this is the first study to use a real environmental instrument; the only

Our first set of main results does not find any significant differences in subjects' time preferences across the monetary and environmental domains. Assuming away any philosophical or ethical issues that might dictate what the discount rate *ought* to be in environmental cost-benefit analysis, a corollary of the first result is that the same discount rate used for financial payoffs should also be used for the environmental ones when evaluating environmental policies. This corollary is reassuring to economists and policy makers who, for some time now, have been evaluating environmental policies with discount rates that are based on the intertemporal-choice framework of the monetary domain.

Our second set of main results finds domain differences in subjects' risk aversion. More specifically, subjects (men and women) exhibit a higher degree of risk aversion in the environmental domain relative to the monetary domain; that is, individuals tend to be more reluctant to take on large gambles with environmental outcomes than with monetary ones. A plausible explanation for the emergence of domain differences in risk aversion could be stemming from individuals' perception on the consequences of climate change − a topic that has been well publicized (Stern (2007)). Furthermore, we corroborate existing results, which document that women are more risk averse than men in the monetary domain. We show this finding to also hold in the environmental domain. The latter findings seem to hint that women are more risk averse than men in most domains. In fact, this conjecture finds support in the study of Weber et al. (2002) who show that women are more risk averse than men in four domains (financial decisions, health/safety, recreational, ethical), but not in the domain of social decisions. The authors attribute this pattern of results to gender differences in the perception of risk.

Finally, our third set of results finds no correlation between subjects' time preferences and their risk aversion within a domain. Given that the experiment has jointly generated data on intertemporal choices and risk aversion, we examine next whether indeed the two decision types are correlated within a domain. However, this is not the

other study that we are aware of that investigates differences in time preferences across the monetary and the environmental domains used hypothetical environmental payoffs (Hardisty and Weber (2009)).

case. Moreover, we do not find any support of the hypothesis that time preferences or risk aversion are correlated with subjects' cognitive abilities or environmental awareness.

The paper adheres to the following plan. We present next an overview of the related literature. Section 3 describes, in relative detail, the experimental design. Section 4 presents the data analysis, and Section 5 discusses the important findings and provides direction for future research.

2.2 Literature Review

Our paper is related to two main strands of the literature on decision-making across domains. First, it is related to the growing literature on domain differences in time preferences. The impact of domains on intertemporal choice has predominantly revolved around the monetary domain and the health domain, where most studies find differences in subjects' discounting behavior.[3] In the midst of a public debate on the appropriate discount rate to evaluate the consequences of climate change (Stern (2007); Nordhaus (2007); Pizer et al. (2014); Arrow et al. (2014)),[4] it is important to go back to the fundamental reason we even consider discounting in the first place, it is because of the preferences of individuals that penalise outcomes that occur with a delay by assigning a lower utility weight to them. Discounting is such an integral part of policy evaluation because of the way that people attach preferences to immediate returns over those that take a long time to materialise. This research moves away from the ethical debate in

[3]Many studies find that discount rates in the health domain are larger than those in the monetary domain for health gains, but lower than those in the monetary domain for health losses (Cairns (1992); Chapman and Elstein (1995); Madden et al. (1999)).

[4]As Weitzman (2007) aptly notes, "it is not an exaggeration to say that the biggest uncertainty of all in the economics of climate change is the uncertainty about which interest rate to use for discounting" (p. 705).

these papers and focuses our attention back on the source of discounting, people's preferences. In particular it focuses on the impact of decision domains on the risk and time preferences elicited.

The investigation on the impact of domains on intertemporal choice has expanded to also include the environmental domain. In their study, Hardisty and Weber (2009) compare intertemporal choices elicited in the money, health and environment domains by eliciting discount rates for the following goods: air quality improvements or deterioration, garbage pile-ups, improvement to mass transit, improvement in current poor health, and acquiring a disease. They find that subjects' discounting behavior is not statistically different across the environmental and monetary domains, but is statistically different across the health domain and the other two domains. Hardisty and Weber (2009) attribute the domain effect in health to subjects' visceral reaction to the health scenarios. Other studies have also assessed the discounting behavior of subjects in the environmental domain albeit via risk assessments. Böhm and Pfister (2005), for example, conduct experiments to measure subjects' risk assessment of hypothetical scenarios on coastal erosion and marine oil spills. The authors find that temporal discounting of environmental risks is weak and postulate that ethical evaluations are not discounted by subjects. In their review on temporal discounting of environmental risks, Gattig and Hendrickx (2007) conclude that temporal discounting is less pronounced for environmental risks than for risks in other domains. Finally, Viscusi et al. (2008) estimate discounting rates based on a series of environmental policy choices on water quality improvement administered in a survey context using a discrete choice experiment. A key finding of their study is that discounting behavior differs markedly for people who visit lakes, rivers and streams for recreational purposes and those who do not. More specifically, regular visitors to water bodies have low discounting rates, whereas those who do not visit water bodies often have consistently high discounting rates.

Our work is also related to the literature on risk preferences across domains. Weber et al. (2002) look at respondents' choices in various domains and find differences in risk taking across domains. However, the authors attribute these differences to different perceptions of the risks in those domains rather than differences in attitude towards those

perceived risks, which they find to be remarkably consistent across domains. In a more recent study, Dohmen et al. (2011) use a large, representative survey of the German population to elicit risk preferences across a number of domains and find that the self-reported, risk-taking measures are highly, but not perfectly, correlated across domains.[5] Finally, in a study with a different flavor, Riddel (2012) compares subjects' evaluation of financial and environmental lotteries to determine whether preferences over environmental risks can be reasonably approximated by the Expected Utility framework. The author finds that subjects are more likely to overemphasise low probability, extreme environmental outcomes than low probability, extreme financial ones. As a result, she concludes that the Expected Utility framework is likely to underestimate subjects' willingness to pay for environmental cleanup programs or policies with uncertain outcomes.

The studies presented subjects with different types of environmental goods. In Hardisty and Weber (2009) the environmental the four goods presented was an improvement and a decrease in air quality, and improvement in mass transit and a decrease in waste management while Viscusi et al. (2008) use improvements in water quality in a local area (without specifying what type of water body they were considering). The choices of environmental goods are always prone to criticism. They are often part private goods (such as the mass transit and waste management) or part health (such as the air quality). When comparing domains such as money and environment these limitations may not be detrimental to the experimental design, however when comparing environment to health domains the importance of choosing a good that lies squarely in one domain without any overlap becomes even more vital.

All the aforementioned studies that pertain to the environmental domain use an elicitation method based on *hypothetical* environmental gains and losses. In sharp contrast, our study uses an incentivized scheme with real monetary and environmental payoffs. The use of real payoffs creates a strong incentive for subjects to display their true preferences and increases the attention given to the task at hand. There is evidence that the

[5]Dohmen et al. (2011) test the following domains: career choices, leisure and recreational activities, financial decisions, health and driving. They use a scale from 1 to 10, with 10 signifying the greatest willingness to take risks.

use of real payoffs might matter in discounting experiments. For instance, Kirby and Marakovi (1995) find that discount rates elicited for real monetary payoffs are higher than those elicited for hypothetical ones. Testing a similar setting, Coller and Williams (1999) are less conclusive in their findings, while Camerer and Hogarth (1999), in a wide survey on the role of real incentives, find no effect on mean performance albeit find a reduction in variance with high financial incentives. The authors note that high incentives improve performance in demanding tasks and reduce generosity and risk-seeking behavior. The effect of incentives is also confirmed in other studies investigating the impact of real payoffs in experiments (Kroll et al. (1988); Cummings et al. (1995)).

2.3 Experimental Design

Our experimental setup featured six tasks. Two of these tasks aimed to investigate subjects' intertemporal choices across the monetary domain and the environmental domain. The two tasks differed solely on the instrument that was discounted; that is, the valuation of the two instruments was identical (see Subsection 2.3.2). In the monetary domain, the instrument that was discounted was money, whereas in the environmental domain the instrument that was discounted was plants. To isolate the effect of domain on intertemporal choices, we used the fixed-sequence choice titration (Harrison and Lau (2005); Andersen et al. (2008); Hardisty and Weber (2009); Andersen et al. (2014)).[6]

[6]Other studies (Raineri and Rachlin (1993); Green et al. (1994)) have used the staircase choice titration method. The latter method presents subjects with an initial binary intertemporal choice that dynamically adapts the subsequent choices depending on the subject's decisions. Finally, a third method is the matching-tasks method (Kirby and Marakovi (1995); Chapman (1996b); Cairns and van der Pol (1999)), where subjects are asked to indicate what amount they would require in order to postpone the receipt of a given outcome by a given time delay. In essence, this method asks subjects to reveal directly the upper bracket of their indifference point. However, Hardisty et al. (2013) note that choice-based measures, such as the fixed-sequence choice titration and the staircase choice titration, are better predictors of real world outcomes than matching tasks. Additionally, the authors point out that the demanding dynamic staircase

In this approach, subjects are presented with a series of binary choices between a fixed amount that is due at one point in time and a larger amount that is due at a later point in time. While the smaller sooner amount is kept fixed, the larger later amount increases successively. The experimental data on the repeated binary intertemporal choices are transformed into a single switching point; the latter produces a discount-rate interval, which contains the indifference point of each subject. Another two tasks aimed to measure the risk aversion of subjects across the monetary domain and the environmental domain. The tests on risk aversion were based on the Eckel-Grossman test (Eckel and Grossman (2002); Eckel and Grossman (2008)) and differed, only, on the measurement instrument. Analogous to the previous setup, in the monetary domain, the test used monetary gambles, whereas in the environmental domain, the test used gambles in plants. In addition to the four aforementioned tasks, subjects were required to take the Cognitive Reflection Test (CRT) and to complete a questionnaire. On one hand, the CRT allowed us to obtain a measure of subjects' cognitive ability to reflect and deliberate in the face of intuitively simple alternatives. On the other hand, the questionnaire allowed us to elicit subjects' environmental attitudes.[7] In summary, the addition of the latter two tasks served to provide insights into possible individual heterogeneity that could be related to the way different domains were evaluated by subjects.

Our experimental design applied a hybrid of a 'within-subject' and 'between-subject' design (Charness et al. (2012)). In line with a standard 'within-subject' design, each subject was exposed sequentially to the six tasks. We safeguarded against the possibility of observing order effects by splitting the sample into four subsamples (A1, A2, B1 and B2). The four subsamples differed only in the order the first four tasks were presented (i.e. the monetary discounting task, the monetary risk aversion test, the environmental discounting task and the environmental risk aversion test), thereby replicating a 'between-design' for these four tasks. This allowed us to harness the strength of each design while safeguarding against possible confounds. The experimental design

titration offers no advantages over the simpler fixed-sequence choice titration, making the latter the most appropriate method for this experiment.

[7]The questions were taken from the Segmentation Model created by the Department for Environment, Food & Rural Affairs (DEFRA (2008)).

is indicated in Table 2.1. In Panel A, we provide a brief description of the task and the corresponding acronym. In Panel B, we display the order of the tasks in the four subsamples.

Table 2.1: EXPERIMENTAL DESIGN

Panel A

Task	Acronym
Monetary Discounting	MD
Monetary Risk Aversion Test	MRAT
Environmental Discounting	ED
Environmental Risk Aversion Test	ERAT
Cognitive Reflection Test	CRT
Questionnaire	Q

Panel B

	Subsamples			
Stage	A1	A2	B1	B2
1	MD	MRAT	ED	ERAT
2	MRAT	MD	ERAT	ED
3	ED	ERAT	MD	MRAT
4	ERAT	ED	MRAT	MD
5	CRT	CRT	CRT	CRT
6	Q	Q	Q	Q
# of Subjects	31	31	27	29
# of Sessions	2	2	2	2

Notes: In Panel A, we provide a brief description of the task and the corresponding acronym. In Panel B, we display the order of the tasks in the four subsamples. The last 2 tasks were common in all four subsamples. The first four tasks (MD, MRAT, ED and ERAT) were shuffled across the four subsamples. The last two rows, display the total number of participants and the number of sessions in each subsample.

2.3.1 Environmental Instrument

Our choice for the appropriate environmental instrument was not an easy one. First, we required that the instrument is divisible so as to enable us to vary the larger later amount and the gambles. Second, the instrument had to be familiar to subjects and credible. It had to be familiar to subjects to facilitate their understanding of its potential benefits as well as credible so that subjects could rest assured that the project is one that can be easily implemented without arousing suspicion of deception. The choice of a locally-based project that distributed bee-friendly plants fulfilled all these requirements. Subjects were instructed that bee-friendly plants would be handed out to staff and students on campus to be placed in outdoor areas. Given the different delay periods, different bee-friendly plants were chosen. Subjects were informed that the plants distributed would be chosen depending on the season to ensure that they are immediately beneficial.

The environmental project was described in a succinct and neutral manner. The link between bee-friendly plants and the positive externality they generate was stated in the description. We also stated the fact that bee populations are in decline. These two facts are central to the placing of the project as an environmentally beneficial one. A total of 63 plants were distributed in the experiment. The full description of the project is reported in the Appendix.

2.3.2 Valuation of a Bee-Friendly Plant

In order to ensure that the magnitude of the choices in the monetary domain matched that of the choices in the environmental domain, prior to the experimental sessions, we calibrated the value of a bee-friendly plant using two contingent valuation studies carried out at the University of Southampton. For calibration purposes we wanted to elicit the value individuals assigned to the good being used, which may vary from market prices of the good. This is why we carried out a contingent valuation survey. Plants

are not an unfamiliar good so there is a possibility that the value elicited was influenced by market prices, however, our calibration allowed individuals to freely express their own preferences rather than imposing one value based upon market forces. [8] Subjects participating in these studies were given the same project description that was used in the experimental sessions.

Each study consisted of 81 students of the University of Southampton. The two studies were carried out over the December 2013 - January 2014 period and were carried out face to face within a lecture-hall setting. There was no pretest carried out, with the first study feeding into the set-up of the second. Both studies were of a hypothetical nature and asked participants whether they would be happy to contribute a monetary amount out of their income to fund one bee-friendly plant in a project that was planting bee-friendly plants. The first contingent valuation study presented subjects with an open-ended question asking them to indicate their maximum willingness to pay to contribute one extra plant to the project. The purpose of this study was to allow for the calibration of the values to be used in the second study. The median value of subjects' responses was £5. The top five modal values were utilized in the second contingent valuation study, which presented subjects with *only* one out of the five possible values. Subjects were asked whether they were willing to pay that particular amount to contribute one extra bee-friendly plant to the project. The sample was split between the five values, with 17 subjects responding to the first value of £0.50, 15 subjects responding to the second value of £2.50, 17 subjects responding to the third value of £5.00, 16 subjects responding to the fourth value of £10.00 and 16 subjects responding to the final value of £15.00. The different values presented to respondents and the corresponding acceptance percentages are displayed in Table 2.2. We found that the mean willingness to pay was approximately £4.98.[9] This specific value was close enough to the median

[8] It is well documented in the literature on discounting that small payoffs are discounted more heavily than larger ones. This regularity is referred to as the *magnitude effect* (Frederick et al. (2002)). Our approach minimizes this effect.

[9] The mean willingness to pay was estimated using a probit model with the binary response ('yes' or 'no' to the willingness to pay question) as the dependent variable and the monetary value displayed to the subject as the only explanatory variable along with a constant term.

response in the open-ended question of the first study. Consequently, we rounded the number to the nearest pound, and implemented a conversion rate of 1 plant = £5. Subjects were therefore presented with choices starting at £50 in the monetary domain and 10 plants in the environmental domain. The plants that were distributed were purchased for £3 to £5 each.

Table 2.2: VALUATION OF A BEE-FRIENDLY PLANT

Value Presented	Acceptance Rate
£0.50	88 %
£2.50	60 %
£5.00	41 %
£10.00	19 %
£15.00	6 %

Notes: In the first column, the monetary values that were presented to respondents in the second contingent valuation study are displayed. Subjects were presented with *only* one out of the five possible values. Subjects were asked whether they were willing to pay that particular amount to contribute one extra plant to the project. The sample consisted of 81 subjects who were split between the five values. In the second column, we display the corresponding acceptance percentages; that is, the percentage of subjects who replied that they would be willing to pay that value to contribute one extra plant to the project.

2.3.3 Tasks

All experimental sessions consisted of six stages with one task in each stage. Subjects were informed of the total number of stages at the start of the experimental session, but were introduced to the tasks of the stages as they progressed through the session. The experimental sessions were conducted in the Social Sciences Experimental Lab (SSEL) at the University of Southampton in March and April of 2014. The subjects

were recruited from the student population of the University of Southampton using an electronic recruitment system. Subjects were allowed to participate in *only* one session. A total of 118 students participated in the experiment. The split across gender was almost even: 54% were men and 46% were women. The ages ranged from 18 to 28. The average age was 20 years old. The bigger portion of subjects (around 60%) were pursuing an economics degree. Students pursuing a mathematics degree (around 12%) had also a large representation in the sample, as well as students pursuing a philosophy degree (around 4%). The remaining 24% of the sample were students studying to earn a degree in one of english, history, modern languages, music, chemistry, law, health sciences and geography. 93% of the subjects were undergraduates; the rest pursued postgraduate studies. Each session had at most 16 subjects (this is the maximum capacity of the lab) and lasted approximately 45 minutes. The minimum number of subjects in a session was 13. The total number of subjects in each subsample and the total number of sessions in each subsample are displayed in the last two rows in Panel B of Table 2.1. Each participant received £5 as a participation fee. Since participants took part in all the tasks the expected payoff to participants was the same regardless of which order the tasks were presented. The expected payoff would be slightly smaller in the sessions with a full lab of 16 participants than in the smallest session with 13, and would consist of the probability of selection, 1 over the number of participants in that session, multiplied by the expected payoff per task, which is one over the total questions up for selection multiplied by the outcome of each question.[10] The experimental codes

[10]The expected monetary payoffs for this experiment vary depending on the choices made by the subjects and the number of subjects in the session. For a session with 16 subjects, the largest group we had, they range from £3.9 for a subject that repeatedly selects the smaller sooner outcome and has a mid-level risk aversion (chooses gamble 3 in the risk aversion stage), to £4.6 for a subject that repeatedly selects the larger later outcome and has a mid-level risk aversion (chooses gamble 3 in the risk aversion stage). This is over and above the £5 show-up fee, making the totals £8.9 and £9.6 respectively. For a session with 13 subjects, the smallest group we had, they range from £4.3 for a subject that repeatedly selects the smaller sooner outcome and has a mid-level risk aversion (chooses gamble 3 in the risk aversion stage), to £5.1 for a subject that repeatedly selects the larger later outcome and has a mid-level risk aversion (chooses gamble 3 in the risk aversion stage). This is over and above the 5 show-up fee, making the totals £9.3 and £10.1 respectively.

were programmed using the experimental software z-Tree (Fischbacher (2007)). The experimental instructions are provided in the Appendix.

Monetary Discounting (MD) & Environmental Discounting (ED)

The Monetary Discounting (MD) task presented subjects with choices between a smaller sooner amount and a larger later amount. The smaller sooner amount was kept fixed at £50, whereas the larger later amount started at £55 and progressively increased to £100 (i.e. £60, £65, £70, £75, £100). Subjects were presented with these six choices for three different delay periods: (i) a 3-month delay period, (ii) a 6-month delay period, and (iii) a 12-month delay period. Thus, in total subjects had to respond to $6 \times 3 = 18$ questions. The implied hyperbolic discount-rate brackets in each of the delay periods became progressively smaller. Note that the implied discount-rate brackets were not provided to subjects. In total, we extracted three monetary discount brackets for each subject.[11] The binary choices and the implied hyperbolic discount-rate brackets are displayed in Panel A of Table 2.3. To calculate the implied discount rates, we used the hyperbolic formula $\rho = 12(F/P - 1)/T$, where ρ is the discount rate, F is the future value, P is the present value and T is the time delay (in months) between the present and the future value (Doyle (2013)).[12]

[11] Around 92% of subjects had one switching point. Subjects who switched more than once in two or more discounting tasks were excluded from the analysis on time preferences (see Subsection 2.4.1).

[12] Here, our objective is to investigate subjects' intertemporal choices across the monetary domain and the environmental domain. We remain agnostic as to the actual numerical value of the discount rate. Calculating the actual discount rate is outside the scope of this study. Nevertheless, our qualitative results are robust to consistent changes in the functional form across the two domains.

Table 2.3: BINARY CHOICES AND IMPLIED DISCOUNT-RATE BRACKETS

Panel A

Monetary Discounting (MD)

Binary Choice		Hyperbolic Discount-Rate Brackets		
Smaller sooner (£)	Larger later (£)	3-month (%)	6-month (%)	12-month (%)
50	55	$/-40$	$/-20$	$/-10$
50	60	$40-80$	$20-40$	$10-20$
50	65	$80-120$	$40-60$	$20-30$
50	70	$120-160$	$60-80$	$30-40$
50	75	$160-200$	$80-100$	$40-50$
50	100	$200-400$	$100-200$	$50-100$

Panel B

Environmental Discounting (ED)

Binary Choice		Hyperbolic Discount-Rate Brackets		
Smaller sooner (plants)	Larger later (plants)	3-month (%)	6-month (%)	12-month (%)
10	11	$/-40$	$/-20$	$/-10$
10	12	$40-80$	$20-40$	$10-20$
10	13	$80-120$	$40-60$	$20-30$
10	14	$120-160$	$60-80$	$30-40$
10	15	$160-200$	$80-100$	$40-50$
10	20	$200-400$	$100-200$	$50-100$

Notes: In Panel A, we display the binary choices and the implied hyperbolic discount-rate brackets in the Monetary Discounting (MD) task. In Panel B, we display the binary choices and the implied hyperbolic discount-rate brackets in the Environmental Discounting (ED) task.

All the intertemporal choices presented to participants incorporated a front-end delay as is standard practice in many such experimental studies. Rather than giving subjects an earlier option that is payable at the end of the experimental session, discounting experiments typically make use of a front-end delay where the smaller sooner choice is itself delayed by a short time period (Coller and Williams (1999); Andersen et al. (2008)). The main advantage of this approach is that the front-end delay safeguards against possible confounding effects caused by any perceived transaction costs being associated with the larger later payment (Harrison and Lau (2005)).

The payment method was designed to further reduce any perceived transaction costs. Subjects were given a requisition form at the end of the experimental session, which detailed their payoffs. The requisition form had to be dropped off at the Finance Office (in the School of Social Sciences at the University of Southampton) and participants were paid by direct debit by the Finance Office on the date specified on the form. The precise process was explained in the experimental instructions.

In the Environmental Discounting (ED) task, subjects were presented with the same setup as in the MD task; that is, six binary choices were displayed for each of the (three) different delay periods. Analogous to the task above, three environmental discount brackets were obtained for each subject. The only difference between this task and the previous one is that subjects were presented with the environmental instrument (i.e. plants) instead of money. The binary choices presented to subjects and the implied hyperbolic discount-rate brackets are displayed in Panel B of Table 2.2.

Monetary Risk Aversion Test (MRAT) & Environmental Risk Aversion Test (ERAT)

The two tests served to elicit subjects' risk aversion in the monetary domain and the environmental domain. We used a variant of the Eckel-Grossman test (Eckel and Grossman (2002); Eckel and Grossman (2008)), where subjects were presented with five gambles of varying riskiness and were required to select the one they prefer. The Eckel-Grossman test was designed to maximize the simplicity of the task for participants. This

test is a simplified version of the risk aversion test designed by Holt and Laury (Holt and Laury (2002), while still eliciting sufficient heterogeneity in subjects' responses (Eckel and Grossman (2008)), however both of these remain popular tests for estimating risk aversion. All gambles had two possible outcomes: Outcome X with 50% likelihood and Outcome Y with 50% likelihood; that is, both outcomes were equiprobable. In addition, the expected payoffs were easy to calculate and the increasing variance as the gambles got riskier was significantly large to be noticeable.

Table 2.4: RISK AVERSION TESTS

Panel A

Monetary Risk Aversion Test (MRAT)

Option	Outcome	Payoffs (£)	Probability
1	X	50.00	50%
	Y	50.00	50%
2	X	35.00	50%
	Y	87.50	50%
3	X	25.00	50%
	Y	112.50	50%
4	X	15.00	50%
	Y	137.50	50%
5	X	5.00	50%
	Y	162.50	50%

Panel B

Environmental Risk Aversion Test (ERAT)

Option	Outcome	Payoffs (plants)	Probability
1	X	10 plants	50%
	Y	10 plants	50%
2	X	7 plants	50%
	Y	18 plants	50%
3	X	5 plants	50%
	Y	23 plants	50%
4	X	3 plants	50%
	Y	28 plants	50%
5	X	1 plant	50%
	Y	33 plants	50%

Notes: Panel A displays the Monetary Risk Aversion Test (MRAT). Panel B displays the Environmental Risk Aversion Test (ERAT). Both panels follow the same structure. In the first column, the 5 options available to subjects are listed. In the second column, the possible outcomes of each option are listed:

The Monetary Risk Aversion Test (MRAT) was set at a magnitude level that was comparable to the choices given to subjects in the discounting tasks. The gambles started at an option with identical outcomes (i.e. a gain of £50) and moved to options of increasing variance at the point where the last option's equiprobable outcomes were £5 and £162.50. Expected payoffs increased as you moved down the table, so choices further down indicated *lower* risk aversion. The Environmental Risk Aversion Test (ERAT) was matched in magnitude to the MRAT at the same conversion rate of money per plant (£5 per plant) used in the discounting tasks. Analogous to the MRAT, the first option had identical outcomes, whereas the last option's equiprobable outcomes were 1 plant and 33 plants. The lists of gambles presented in the MRAT and the ERAT are displayed in Panel A and Panel B, respectively, in Table 2.4.

Cognitive Reflection Test (CRT) & Questionnaire (Q)

The Cognitive Reflection Test (CRT) was proposed by Frederick (2005) as a way of measuring a specific type of cognitive ability − that of suppressing a spontaneous response in favor of a more deliberately-thought-out one. This specific skill has been found to be correlated with individual time preferences (Frederick (2005)). The CRT consists of 3 questions. In order to successfully complete the CRT subjects were required to question their initial response and devote some cognitive power to realize that it was incorrect and, consequently, arrive at the correct answer. The inclusion of the CRT task allows us to capture the heterogeneity in subjects' reflective ability. More specifically, cognitive ability could plausibly be increasingly relevant to the evaluation of intertemporal (monetary and environmental) choices and (monetary and environmental) risk aversion. The three CRT questions are included in the Appendix.

Finally, in the last stage, we administered the Questionnaire (Q). The questionnaire consisted of questions of socio-demographic nature as well as 17 questions taken from the Segmentation Model developed by DEFRA (2008).[13] The latter part pertained to

[13]The model segments the population into seven behavioral groups using a number of questions on

subjects' values, attitudes and motivations as well as current behaviors and barriers to change. In addition, the questions covered topics, such as climate change, recycling, transportation and water use. These questions were included in order to allow us to test whether these variables influence the discounting and risk behaviour of subjects. The Q was administered in the last stage in order to remove any unintentional impact these questions might have on the environmental intertemporal choices and environmental risk aversion of subjects.

2.3.4 Payment Mechanism

The experimental design applied a variant of the random-lottery incentive scheme, where subjects make a number of decisions knowing that, at the end of the experimental session, one of these decisions will be selected for payment. There is a vast literature testing the validity of this payment scheme. Laury (2012) found that subjects do not scale down decisions when they are only being paid for a subset of these decisions. Along the same lines, Cubitt et al. (1998) confirmed that such design does not contaminate elicited preferences. Hey and Lee (2005) showed that subjects separate the various questions and respond to each question individually and in isolation from the rest; thus, incentives are retained. Recently, Andersen et al. (2014) find no evidence that the use of probabilistic payment schemes on discount rates change behavior relative to that in a fully-paid experiment. A value-added of this approach is that it neutralizes the income effect that would otherwise be experienced as subjects progress through the

environmental attitudes and the respondents' age. DEFRA has developed this model in order to further advance behavioral change through social marketing strategies that target specific segments of the population. Their objective is to achieve a more environmentally-friendly lifestyle for the public. Segmentation models are a popular way of investigating the behavior of individuals as it pertains to specific functions of their everyday life, such as transportation choices and water consumption. The advantage of the DEFRA model is that it targets attitudes towards many different environmental sectors, thus achieving a classification that captures an individual's overall attitude to issues of an environmental nature (Jesson (2009); Barr et al. (2011)).

periods. Our approach was to apply a double layered random-lottery incentive payment scheme. More specifically, two subjects in each experimental session were randomly selected to be paid for their choices. The first subject selected was paid for either the choice made in the MD task or the choice made in the ED task, where each task had an equal probability of being selected. Once the domain was selected, one of the 18 questions was drawn and the subject's choice in that question was paid (with money or plants accordingly). The second subject selected was paid for either the choice made in the MRAT or the choice made in the ERAT, where each test had an equal probability of being selected. Once the test was selected, an outcome was drawn (X or Y where each outcome had an equal probability of being selected) and the subject was paid (with money or plants accordingly) based on the gamble chosen.

The random selection was carried out using a bingo machine that was prominently displayed in the lab. Bingo balls were placed on subjects' desks with the terminal ID number on the ball. Subjects placed the balls into the bingo machine themselves at the end of the experimental session and witnessed the random selection. This was necessary to ensure complete transparency of the process. However, the choices of the subjects selected were not revealed to the other subjects as that would violate the confidentiality with respect to their earnings.

Any monetary earnings were paid using University of Southampton requisition invoices. In the case of payments for the discounting tasks, the invoice date reflected the time delay associated with the chosen question.

2.3.5 General Hypotheses

Based on the existing literature (Hardisty and Weber (2009)), we first hypothesize that the domain has no impact on subjects' intertemporal choices. This hypothesis is tested by comparing the intertemporal choices taken in the monetary domain with those taken in the environmental domain. The first hypothesis is thus formulated as follows.

H1: Subjects' intertemporal choices are the same across the monetary domain and the environmental domain.

In an analogous manner, we hypothesize that subjects' risk aversion is not influenced by the domain. The second hypothesis is stated next.

H2: Subjects' risk aversion is the same across the monetary domain and the environmental domain.

Our last hypothesis is formulated to determine whether there exists some degree of correlation between the two decision types within a domain.

H3: Subjects' intertemporal choices correlate with their risk aversion within a domain.

2.4 Results

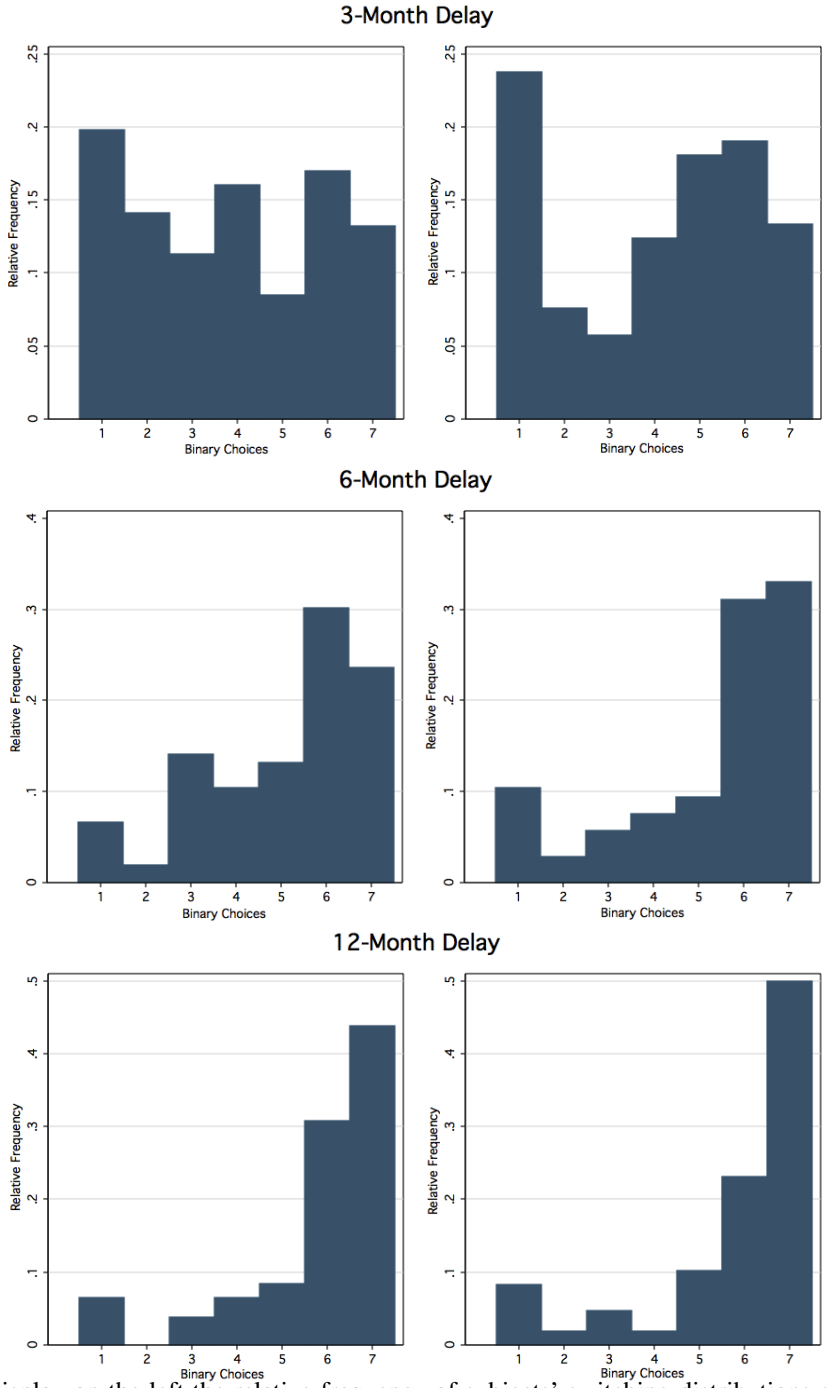
The three hypotheses are formally tested next. Each hypothesis is matched with the corresponding result; that is, result i is a report on the test of hypothesis i.

2.4.1 Descriptive Statistics

Time Preferences

Recall that subjects had to decide on the switching point in the 3-month delay period, the 6-month delay period, the 12-month delay period for both the monetary and the environmental domains. Subjects that switched twice within the same time-delay period in two or more discounting tasks were taken out of the data analysis on time preferences. A total of 10 subjects were excluded leaving us with 108 observations.

Figure 2.1: SWITCHING DISTRIBUTION



Notes: We display on the left the relative frequency of subjects' switching distributions across the discounting tasks in the monetary domain. We display on the right the relative frequency of subjects' switching distributions across the discounting tasks in the environmental domain. An individual with a binary choice of 1 in the monetary domain, chose the larger later amount of £55 in lieu of the earlier smaller amount of £50 and an individual with a binary choice of 1 in the environmental domain, chose the larger later amount of 11 plants in lieu of the earlier smaller amount of 10 plants. An individual with a binary choice of 7 in either the monetary or the environmental domain, always chose the earlier smaller amount.

We present next the switching distribution of subjects in the three delay periods in the monetary domain and in the three delay periods in the environmental domain. This information is displayed in Figure 2.1. An individual with a binary choice of 1 in the monetary domain, chose the larger later amount of £55 in lieu of the earlier smaller amount of £50 and an individual with a binary choice of 1 in the environmental domain, chose the larger later amount of 11 plants in lieu of the earlier smaller amount of 10 plants. An individual with a binary choice of 7 in either the monetary or the environmental domain, always chose the earlier smaller amount. The mean switch in the 3-month delay period (MD 3.8/ED 4.0) implies an annual discount-rate bracket between 80% and 160%. The mean switch in the 6-month delay period (MD 5.1/ED 5.3) implies an average discount-rate bracket between 80% and 200%. Finally, the mean switch in the 12-month delay period (MD 5.5/ED 5.7) implies an average discount-rate bracket between 40% and 100%.

We next allocate subjects into three categories based on their discounting behavior in the monetary domain and the environmental domain while controlling for the time delay. More specifically, we provide the frequency and percentage of subjects that exhibited one of the three discounting patterns: (i) constant discounting across domains, (ii) higher discounting in the environmental domain, and (iii) lower discounting in the environmental domain. The findings are displayed in Table 2.5. Over the three time-delay periods, on average, the number of subjects that exhibited a constant discounting behavior across the two domains was 30%, 40% of the subjects exhibited a higher discount rate in the environmental domain, and 30% of the subjects exhibited a lower discount rate in the environmental domain.

Table 2.5: DISCOUNTING PATTERNS ACROSS DOMAINS

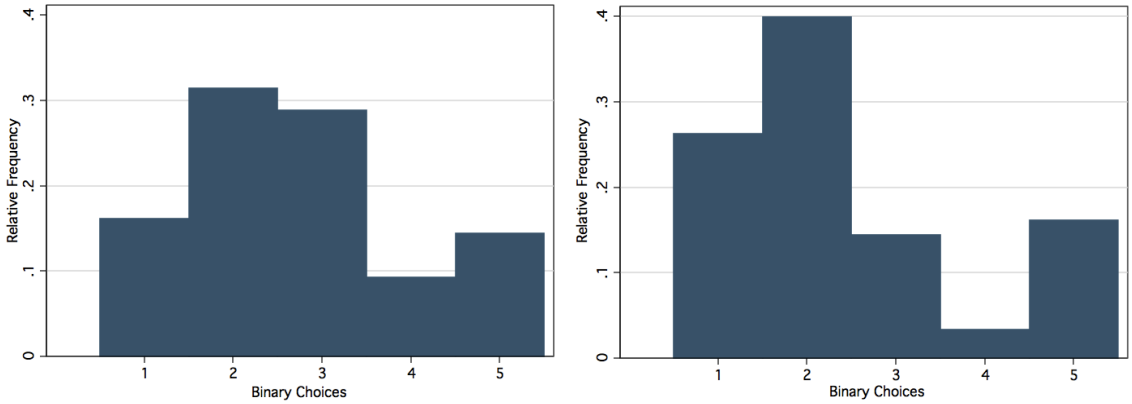
Time Delay:	3-month		6-month		12-month	
	Freq.	%	Freq.	%	Freq.	%
Constant discounting across domains	27	25	29	27	42	39
Higher environmental discounting	46	43	48	44	35	32
Lower environmental discounting	35	32	31	29	31	29
Total	108		108		108	

Notes: We display information on subjects' discounting behavior in the monetary domain and the environmental domain while controlling for the time delay.

Risk Aversion

In the tests on risk aversion, subjects were given five gambles to choose from, where each gamble featured two possible outcomes: Outcome X with 50% likelihood and Outcome Y with 50% likelihood. The gambles started at a non-degenerate gamble and moved to degenerate gambles of increasing variance and expected payoffs. In the Monetary Risk Aversion Test (MRAT), 18% of subjects chose the non-degenerate gamble, 59% of subjects chose one of the next two gambles, while the remaining 23% chose one of the last two gambles. In the Environmental Risk Aversion Test (ERAT), 28% of subjects chose the non-degenerate gamble, 54% of subjects chose one of the next two gambles, and the remaining 18% chose one of the last two gambles. The relative frequency of subjects' gambles across the MRAT and ERAT is displayed in Figure 2.2.

Figure 2.2: DISTRIBUTION OF RISK AVERSION

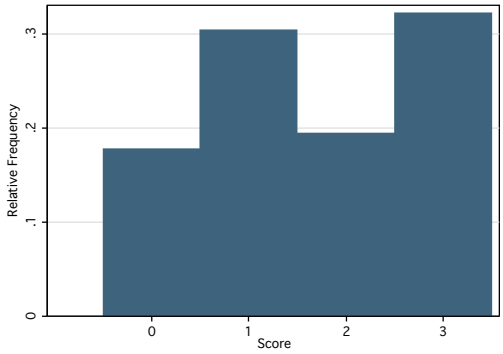


Notes: We display on the left the relative frequency of subjects' gambles across the MRAT. We display on the right the relative frequency of subjects' gambles across the ERAT. Binary choices indicate the gambles chosen by the subjects.

Cognitive Reflection Test & Questionnaire

The Cognitive Reflection Test (CRT) aims to measure subjects' reflective ability. The test requires subjects to answer three questions, where each question has 4 possible answers. The CRT score consists of one positive point for every correct answer given. The score therefore ranges from 0 to 3. 34% of the subjects answered all three questions correctly, while 18% of subjects got all three questions wrong. The spread of scores suggests a dispersion of reflective ability amongst subjects. The distribution for the CRT is shown in Figure 2.3.

Figure 2.3: DISTRIBUTION OF CRT SCORES



Notes: We report the relative frequency of subjects' CRT scores. The CRT score consists of one positive point for every correct answer given.

Table 2.6: SEGMENTATION MODEL

Questions
I would only travel by bus if I had no other choice. (PG:3.25; WW:5.33; CC:2.91; SS:6.23; CP:4.14; StSt:5.08; HD:5.48)
For the sake of the environment, car users should pay higher taxes. (PG:5.33; WW:1.87; CC:3.07; SS:3.00; CP:4.90; StSt:3.43; HD:2.62)
People who fly should bear the cost of the environmental damage that air travel causes. (PG:7.44; WW:3.51; CC:4.63; SS:5.15; CP:6.84; StSt:4.70; HD:3.13)
I don't pay much attention to the amount of water I use. (PG:5.11; WW:4.71; CC:5.48; SS:11.22; CP:6.04; StSt:10.01; HD:8.59)
People have a duty to recycle. (PG:17.90; WW:17.37; CC:16.80; SS:17.25; CP:17.03; StSt:17.87; HD:13.30)
We are close to the limit of the number of people that earth can support. (PG:5.23; WW:5.91; CC:2.70; SS:5.60; CP:5.13; StSt:6.64; HD:4.48)
The earth has very limited room and resources. (PG:10.90; WW:9.28; CC:6.73; SS:9.77; CP:8.58; StSt:8.94; HD:7.09)
If things continue on their current course, we will soon experience a major environmental disaster. (PG:15.70; WW:13.51; CC:13.19; SS:15.31; CP:14.75; StSt:16.59; HD:11.19)
The so-called 'environmental crisis' facing humanity has been greatly exaggerated. (PG:7.18; WW:11.42; CC:9.54; SS:8.91; CP:9.77; StSt:12.98; HD:11.94)
It would embarrass me if my friends thought my lifestyle was purposefully environmentally friendly. (PG:1.67; WW:3.23; CC:3.24; SS:3.74; CP:6.06; StSt:8.55; HD:5.34)
Being green is an alternative lifestyle, it's not for the majority. (PG:2.71; WW:4.71; CC:4.27; SS:6.24; CP:5.56; StSt:8.12; HD:6.61)
I find it hard to change my habits to be more environmentally friendly. (PG:6.77; WW:7.12; CC:7.03; SS:9.47; CP:9.60; StSt:11.89; HD:9.77)
It's only worth doing environmentally-friendly things if they save you money. (PG:3.02; WW:4.54; CC:4.93; SS:4.72; CP:6.73; StSt:11.29; HD:7.84)
The effects of climate change are too far in the future to really worry me. (PG:0.46; WW:3.17; CC:2.80; SS:3.56; CP:4.03; StSt:9.34; HD:6.87)
It's not worth me doing things to help the environment if others don't do the same. (PG:1.19; WW:2.71; CC:2.66; SS:3.42; CP:5.91; StSt:8.09; HD:6.58)
It's not worth Britain trying to combat climate change, other countries will just cancel what we do. (PG:1.18; WW:5.94; CC:1.70; SS:3.53; CP:5.25; StSt:6.21; HD:5.33)
Which of these best describes how you feel about your current lifestyle and the environment? (PG:7.41; WW:3.01; CC:5.56; SS:5.44; CP:6.19; StSt:3.37; HD:2.53)

Notes: We display the questions of the Segmentation Model that classifies respondents into Positive Greens (PG), Waste Watchers (WW), Concerned Consumers (CC), Sideline Supporters (SS), Cautious Participants (CP), Stalled Starters (StSt) and Honestly Disengaged (HD). Each respondent receives 7 scores, one for each behavioral group. The respondent is placed in the group with the *highest* score. The score of the group is calculated as follows: (i) multiply the unique group coefficient of each question (indicated in brackets) with a scale from 0 to 1 based on the respondent's corresponding answer ('Strongly agree'=1, 'Tend to agree'=0.75, 'Neither agree nor disagree'=0.5, 'Don't know'=0.25, and 'Strongly disagree'=0; in the last question, the possible responses were: 'I'd like to do a lot more to help the environment'=1, 'I'd like to do a bit more to help the environment'=0.5, 'I'm happy with what I do at the moment'=0, and 'Don't know'=0.5), (ii) sum the group's products of the 17 questions, (iii) add to the sum in (ii) the product of the respondent's age (16-29=1, 30-40=2, 41-54=3, 55-64=4, and 65^{+}=5) and the group's coefficient (PG:1.70, WW:1.75, CC:1.48, SS:1.64, CP:1.53, StSt:1.62, HD:1.50), and (iv) add to (iii) the group's constant (PG:-35.32, WW:-34.28; CC:-26.89, SS:-40.44, CP:-40.02, StSt:-56.70, HD:-35.45).

Table 2.7: BEHAVIORAL GROUPS

Groups	Freq.	%
Positive Greens	39	33.1
Waste Watchers	6	5.1
Concerned Consumers	30	25.4
Sideline Supporters	16	13.6
Cautious Participants	12	10.2
Stalled Starters	6	5.1
Honestly Disengaged	9	7.6

Notes: We classify the 118 respondents into 7 behavioral groups based on the Segmentation Model developed by DEFRA (2008).

The questionnaire consisted of questions of socio-demographic nature as well as 17 questions taken from the Segmentation Model developed by DEFRA (2008). The questions from the Segmentation Model are provided in Table 2.6. The model segments the respondents into 7 behavioral groups. The frequencies and corresponding percentages of the seven groups are displayed in Table 2.7. The first four groups are considered pro-environmental. In our sample, almost 78% of the respondents belong to one of the top four pro-environmental groups. We further classify subjects that belong to the top four groups as exhibiting *environmental awareness*.

2.4.2 Order Effects

The principal drawback of a 'within-subject' experimental design is the possibility that the order in which the subjects are presented with the tasks might influence their choices. Recall that in our setup, we allowed for four subsamples: A1, A2, B1 and B2 (see Table 2.1). In Table 2.8, we use the Bonferroni adjustment, which corrects for multiple

comparisons in the p-values to determine whether subjects' choice in a specific task differs ($i \neq j$) across the pairwise, subsample comparison. Rejecting the null would imply that the setup is confounded with order effects. Yet, our design does not seem to be susceptible to order effects. Consistency checks using the Šidák and the Scheffé adjustments yield similar results.

Table 2.8: ORDER EFFECTS

Subsamples	A2/A1	B1/A2	B1/A1	B2/B1	B2/A2	B2/A1
Alternative hypothesis:		$choice_i \neq choice_j$				
		p-values				
Time Preferences						
MD (3-month delay)	1.000	1.000	1.000	1.000	0.196	0.083
MD (6-month delay)	1.000	1.000	1.000	1.000	0.511	0.326
MD (12-month delay)	1.000	1.000	1.000	1.000	1.000	0.625
ED (3-month delay)	0.781	1.000	1.000	0.869	0.264	0.251
ED (6-month delay)	1.000	1.000	1.000	1.000	1.000	0.165
ED (12-month delay)	1.000	1.000	1.000	1.000	0.429	0.240
Risk Aversion						
MRAT	0.910	1.000	1.000	1.000	1.000	1.000
ERAT	1.000	1.000	1.000	1.000	0.413	0.145

Notes: We use the Bonferroni adjustment, which corrects for multiple comparisons in the p-values to determine whether subjects' choice in a specific task differs ($i \neq j$) across the pairwise, subsample comparison.

2.4.3 Domain Differences

The first hypothesis aims to determine whether a change in domain has an effect on subjects' intertemporal choices. We first test our hypothesis using a standard χ^2-test, where the H_0 states that the intertemporal choices across the monetary and the environmental domains are similar when controlling for the time delay. The results are displayed in Table 2.9, where we report the p-values in the full sample and each subsample. The χ^2-test does not find any significant differences in discounting across domains; thus, we cannot reject the H_0.

Table 2.9: χ^2-TESTS ON DOMAIN DIFFERENCES IN TIME PREFERENCES

Subsamples	All	A1	A2	B1	B2
Alternative hypothesis:		MD $\neq$ ED			
		p-values			
3-Month	0.192	0.100	0.404	0.354	0.442
6-Month	0.256	0.728	0.888	0.346	0.164
12-Month	0.328	0.222	0.403	0.802	0.359

Notes: We report p-values from the χ^2-test for each of the four treatment groups (A1, A2, B1 and B2) for the responses collected for each of the three delays each respondent was faced with, where the H_0 states that the discounting behavior across the monetary and the environmental domains is similar when controlling for the time delay.

Moreover, given the repeated nature of the tasks undertaken, we also run two mixed-effects ordered probit regressions in Table 2.10 with subjects' intertemporal choices as the categorical dependent variable. For the probit regressions, we utilized the full sample as such regressions require a sufficiently large sample size otherwise the statistical power of the test is significantly compromised. Domain is an explanatory dummy re-

gression variable, which takes the value of 1 if the intertemporal choices have been obtained from the ED and 0 if the intertemporal choices have been obtained from the MD.

We investigate two specifications: Model 1 and Model 2. Model 1 incorporates only the domain dummy. Model 2 builds upon the first model by adding a gender variable, an interaction variable between gender and domain, a variable on whether the subject's parents own their home, a variable on whether the subject belongs in one of the top four, pro-environmental groups of DEFRA (2008) (i.e. exhibits environmental awareness), and a variable on whether the subject scored at least 2 questions correctly on the CRT. The inclusion of gender as an explanatory variable stems from literature on risk aversion which has found significant gender effects in risk aversion (Charness et al. (2012)). The inclusion of parental ownership of home serves as an income variable proxy, given that the subjects are university students, parental financial stability is considered to be an appropriate proxy for individual financial stability. The environmental awareness variable was included as a way to allow for the identification of subject heterogeneity in environmental attitudes as potential influence on environmental discounting and risk preferences. The CRT has been shown to be correlated to discounting behavior (Frederick (2005)) and has been used, with mixed results, in discounting experiments since (Hardisty and Weber (2009)).

The earlier findings are confirmed; that is, no significant differences in subjects' intertemporal choices seem to exist across the monetary and the environmental domains. Our findings are formalized next in our first main result.

Table 2.10: MIXED-EFFECTS ORDERED PROBIT RESULTS ON DOMAIN DIFFERENCES IN TIME PREFERENCES

Variables	Model 1	Model 2
Domain	0.106	0.189
	(0.087)	(0.119)
Gender		-0.110
		(0.203)
Domain × Gender		-0.181
		(0.174)
Own home		-0.125
		(0.234)
Environmental awareness		-0.322
		(0.214)
High CRT		-0.185
		(0.186)

Notes: A subject's intertemporal choice is the categorical dependent variable. The two models vary in the number of explanatory variables included. 'Domain' is a dummy that takes the value of 1 in the environmental domain and 0 in the monetary domain, 'Gender' is a dummy that takes the value of 1 if the subject is female and 0 otherwise, 'Domain × Gender' is an interaction variable for the previous two dummies, 'Own home' is a dummy that takes the value of 1 if the subject's parents own their home and 0 otherwise, 'Environmental awareness' is a dummy that takes the value of 1 if the subject belongs in one of the top four, pro-environmental groups of DEFRA (2008) and 0 otherwise, and 'High CRT' is a dummy that takes the value of 1 if the subject scored at least 2 questions correctly on the CRT and 0 otherwise. At an alpha level of 0.05, the power of estimating a 0.5 unit change in the mean switching point is 0.71 while the power of estimating a 1 unit change in the mean switching point is 0.99. All standard errors are reported in parentheses. * Significant at the 10% level ** Significant at the 5% level *** Significant at the 1% level.

R1: Subjects' intertemporal choices are the same across the monetary and the environmental domains.

Recall that the experimental data on the repeated binary intertemporal choices are transformed into a single switching point; the latter produces a discount-rate interval, which contains the indifference point of each subject. Given that the data is of an interval nature and this feature is not captured by the above test, we also run an interval regression, which allows for the specification of the (discount-rate) brackets presented to participants as the dependent variable. More specifically, it allows for the first and last brackets to be open; therefore, the first bracket has no minimum value and the last bracket has no maximum value. The interval regression is run on the log of the discount rates with domain as an explanatory dummy variable, which takes the value of 1 for discounting in the environmental domain and 0 otherwise. The latter model confirms the aforementioned main result.

The second hypothesis aims to determine whether a change in domain has an impact on subjects' risk aversion. We thus run a standard χ^2-test to examine whether subjects' choice in the Eckel Grossman test where they picked their preferred gamble, the variable of interest, is the same across domains using the full sample as well as each subsample. Table 2.11 shows the results of the test. In two of the four subsamples (A1 and B2), there exists evidence to suggest of a domain effect in subjects' choices on gambles. In the full sample, we see that the H_0 is rejected at the 5% level of statistical significance; thus, there exists a domain effect on subjects' risk aversion.

Table 2.11: χ^2-TEST ON DOMAIN DIFFERENCES IN RISK AVERSION

Subsamples	All	A1	A2	B1	B2
Alternative hypothesis:	MRAT $\neq$ ERAT				
	p-values				
	0.011	0.070	0.438	0.328	0.037

Notes: We utilize the χ^2-test in the full sample and each subsample to determine whether subjects' choices on gambles are the same across the two domains.

In addition, analogous to the aforementioned analysis, we also run two mixed-effects ordered probit regressions in Table 2.12 with subjects' choices in the tests on risk aversion as the categorical dependent variable. Crucially, we find that subjects exhibit a higher degree of risk aversion in the environmental domain relative to the monetary domain.[14] These findings culminate in our second main result.

[14] A negative coefficient indicates an increase in the likelihood that a subject will choose one of the earlier (safer) gambles, thereby displaying a higher degree of risk aversion.

Table 2.12: MIXED-EFFECTS ORDERED PROBIT RESULTS ON DOMAIN DIFFERENCES IN RISK AVERSION

Variables	Model 1	Model 2
Domain	-0.403***	-0.381*
	(0.148)	(0.200)
Gender		-0.582**
		(0.272)
Domain × Gender		-0.050
		(0.289)
Own home		0.065
		(0.288)
Environmental awareness		-0.199
		(0.263)
High CRT		-0.215
		(0.231)

Notes: A subject's choice in the risk aversion task is the categorical dependent variable. The two models vary in the number of explanatory variables included. 'Domain' is a dummy that takes the value of 1 in the environmental domain and 0 in the monetary domain, 'Gender' is a dummy that takes the value of 1 if the subject is female and 0 otherwise, 'Domain × Gender' is an interaction variable for the previous two dummies, 'Own home' is a dummy that takes the value of 1 if the subject's parents own their home and 0 otherwise, 'Environmental awareness' is a dummy that takes the value of 1 if the subject belongs in one of the top four, pro-environmental groups of DEFRA (2008) and 0 otherwise, and 'High CRT' is a dummy that takes the value of 1 if the subject scored at least 2 questions correctly on the CRT and 0 otherwise. At an alpha level of 0.05, the power of estimating a 0.3 unit change in the mean risk choice is 0.70 while the power of estimating a 0.5 unit change in the mean risk choice is 0.99. All standard errors are reported in parentheses. * Significant at the 10% level ** Significant at the 5% level *** Significant at the 1% level.

R2: Subjects' risk aversion is statistically different across the monetary and the environmental domains. Specifically, subjects exhibit higher levels of risk aversion in the environmental domain.

Furthermore, it is important to observe that in Model 2 of Table 3.3, the domain and gender regressors are both significant, while the interaction regressor (domain $\times$ gender) is not. This implies that both men and women exhibit higher levels of risk aversion in the environmental domain than in the monetary one, and that women exhibit higher levels of risk aversion than men in both the monetary and the environmental domains. The finding that women are more risk averse than men in the monetary domain corroborates existing results due to Eckel and Grossman (2002). Crucially, we show this finding to also hold in the environmental domain. Finally, we find that neither time preferences nor risk aversion is correlated with CRT or environmental awareness across the two domains.[15]

2.4.4 Time Preferences & Risk Aversion

Part of the motivation for discounting future outcomes rests on the element of risk introduced by the time delay. Given that the experiment has jointly generated data on intertemporal choices and risk aversion, we examine next whether indeed the two decision types are correlated within a domain. The mixed-effects ordered probit regression is displayed in Table 2.13. A subject's choice in the risk aversion task is the categorical dependent variable. The explanatory variables are the switches of the three delay periods; that is, the 3-month, 6-month, and 12-month. In contrast to other authors such as Ferecatu and Önüler (2016) we find no significant correlation between the risk aversion variable and any of the discounting variables. This implies that there is no evidence of an individual's intertemporal choices being related to their choices on risk aversion, which culminates in our last main result.

[15]This is a departure from the findings of Frederick (2005). We conjecture that differences in the experimental design (Frederick's design was not incentivized) can account for the divergence.

R3: Subjects' intertemporal choices show no correlation with their risk aversion within a domain.

Table 2.13: MIXED-EFFECTS ORDERED PROBIT RESULTS ON TIME PREFERENCES & RISK AVERSION

Variables	Model 1
3-month switch	0.001
	(0.071)
6-month switch	0.057
	(0.095)
12-month switch	-0.022
	(0.083)

Notes: A subject's choice in the risk aversion task is the categorical dependent variable. The 3-month switch is a categorical variable representing the choice made in the 3-month delay period. The 6-month switch is a categorical variable representing the choice made in the 6-month delay period. The 12-month switch is a categorical variable representing the choice made in the 12-month delay period. All standard errors are reported in parentheses.

2.5 Concluding Remarks

We study experimentally subjects' time preferences and risk aversion across two domains: the monetary domain and the environmental domain. Our study is the first to utilize an incentivized experimental design: in the monetary domain, time preferences and risk aversion are elicited with real monetary payoffs, whereas in the environmental domain, time preferences and risk aversion are elicited using real, bee-friendly plants.

Contrasting subjects' intertemporal choices across the monetary and environmental domains, we find that subjects' discounting behavior is not statistically different. In sharp contrast, subjects' risk aversion is significantly different across the monetary domain and the environmental domain; specifically, subjects tend to be unwilling to take on large gambles when it comes to bee-friendly plants. This result is not gender-specific; that is, both men and women exhibit a higher degree of risk aversion in the environmental domain relative to the monetary domain. Moreover, we find that women are more risk averse than men in both the monetary and the environmental domains. Finally, given that part of the motivation to discount future outcomes stems from an element of risk, which is introduced by the time delay, we hypothesize that subjects' intertemporal choices correlate with their risk aversion within a domain. Our analysis reveals no such correlation within a domain.

Ideally, these results ought to be evaluated across three important dimensions. First and foremost, the study should be replicated in a more representative sample given that the present sample consisted only of university students. Second, time preferences and risk aversion in the environmental domain should be tested using *other* environmental instruments and compared to time preferences and risk aversion in the monetary domain to determine the robustness of the aforementioned findings. For instance, it would be interesting to include instruments that are closer to resembling private goods, such as energy-saving light bulbs or even instruments that confer little private benefit to the recipient, such as supporting endangered species. Third, time preferences and risk aversion should be tested across a much broader array of domains to identify domain-specificity where such exists. Such fruitful attempts have been undertaken in the recent studies of Tsukayama and Duckworth (2010), and Einav et al. (2012).

It is also important to reflect on issues of power of such experiments. The design of the experiment means that with sample sizes of around 100 subjects we are only really able to detect changes from one switching point level to another. Smaller, subtle changes in discounting preferences are not detectable unless we increase sample size substantially. In order to detect a change of 0.25 in our switching point we would need to increase our sample size to 500 subjects. This has implications to survey design of

future experiments.

Further analysis of the impact of variables such as the CRT and pro-environmental behaviour would also contribute to an improved understanding of the drivers of time and risk preferences. Refinement of the DEFRA segmentation model, by potentially using the key influences rather than the full set of questions, or an updated version of the CRT that has had less visibility than the traditional CRT set up might improve the accuracy of these variables. The current research highlights that a direct mapping of results from the monetary domain to the environmental domain is risky. We believe the same holds true for other domains.

An interesting extension would be the application of models, such as hybrid choice models, that are designed to incorporate preference heterogeneity in the main body of estimation. These models are designed to allow for the incorporation of psychological influences in decision making. They work by extending the random utility model typically used in choice experiments to relax simplifying assumptions and allow for the identification of underlying attitudes that may be influencing the choices we observe (Mariel and Meyerhoff (2016)). In the context of this experiment, it would allow us to identify whether some pro-environmental attitudes are influencing the intertemporal decisions subjects are making. While this extension goes beyond the scope of the hypotheses outlined in this paper, it provides fertile ground for future research on the topic of heterogeneity in intertemporal preferences. This would allow us to further expand our understanding of intertemporal preferences and how they are determined and influenced. This would be especially useful, for example, to behavioural research into the development of nudge policies to encourage a greater consideration of the future impact of current environmental and health decisions.

This research serves to highlight important policy considerations when designing environmental policy that requires people to consider the repercussions of their behavior on environmental outcomes when these occur in the future and with some uncertainty. Individuals are equally myopic when it comes to environmental outcomes, as they are when it comes to monetary outcomes. This persists despite any personal interest in en-

vironmental issues. In addition they are also more risk averse when evaluating environmental outcomes. Environmental policy needs to keep these characteristics in mind and incorporate these obstacles to the rational evaluation of future environmental outcomes by people. This may necessitate stronger policy interventions by authorities seeking improved environmental outcomes.

3

Incentive Effects in Time and Risk Preferences

3.1 Introduction

Choices over uncertain outcomes with a temporal dimension permeate most individual and societal decisions. Investments in education, health or environment require us to quantify preferences over temporal trade-offs and risky choices. Time preference expresses the relative weight given to tomorrow as opposed to today, with individuals commonly choosing benefits that accrue sooner rather than later and therefore discounting future outcomes. With future outcomes embedding an element of uncertainty they are further penalised as individuals recognize their probabilistic nature.

These characteristics, impatience and risk aversion, are mirrored in environmental and health policy appraisals where discount rates, encompassing time preference and risk aversion, are applied to benefits occurring in the future. When balanced out with costs (almost always incurred today), future benefits must be magnitudes greater to

achieve a net-benefit. In practice, discount rates raise the threshold for projects to be considered welfare-increasing and as such, can make or break policy initiatives. Yet, there is very little empirical evidence that can guide the adoption of discount rates in public policy. One main reason for this is the inability of policy makers to measure time preference behaviour where no functioning markets exist. A second best solution would be the use of experimental hypothetical scenarios where contexts and good specific rates could be elicited and subsequently employed in policy evaluation. However, the implicit assumption of external validity for these hypothetical scenarios is a crucial step in moving towards a more evidenced based decision making framework.

This paper focuses on the salient incentivization of subjects participating in economic experiments which has long been considered a fundamental principle that allows for the elicitation of the true nature of participants' preferences, behaviours and choices. Lack of salient incentives is commonly considered to not sufficiently motivate participants to correctly process the task at hand or, at the extreme, to willingly misrepresent their preferences. Understanding the impact of incentives on risk aversion and discounting choices made by subjects is a crucial building block to the wider application of these hypothetical studies.

Previous work on the payoff effect on risk choices has found that in situations involving complex gambles, payoffs have a significant effect on subjects' choices, indicating that more cognitively demanding tasks, or tasks with high stakes, are influenced by incentives (Holt and Laury, 2002). Literature on hypothetical bias in environmental and health valuation studies suggests that the lack of familiarity with the good being evaluated leads to differences in choices when faced with incentivised outcomes (List and Gallet, 2001). In addition, the effect of incentives has been found to be more crucial in situations that involve a temporal dimension where the subject is required to visualise future scenarios, which makes the current investigation of the effect of payoffs on intertemporal choice even more pertinent (Beattie and Loomes, 1997).

Building on past literature, this paper tests the effect of incentives on the mean and variance of responses elicited in risk aversion and discounting tasks for two domains,

monetary and environmental goods. First, we contribute to the overall debate on experimental design and the importance of incentives in risk aversion and time preference experiments and attempt to extract a common message on the possible impact of incentives. Second, we present evidence for environmental economics, and possibly other non-monetary domains, on the reliability and validity of implementing experimental methodology (primarily developed for use with monetary incentives) in hypothetical contexts. To the best of our knowledge this is the first study to do so.

In brief, we find incentives have heterogeneous effects by task (i.e. risk aversion and discounting) and good (i.e. money and environment). Namely, incentives increase the variance for monetary discounting and decrease the mean and variance for environmental discounting responses. Incentives have no impact on the mean or variance for risk aversion tasks. The remainder of the paper proceeds as follows. Section 3.2 briefly presents past literature on the effect of incentivization on risk, discounting and non-strategic games. The experimental design, instrument and analysis is described in Section 3.3 with results being presented in Section 3.4. Section 3.5 discusses our findings and concludes.

3.2 Background

The effect of experimental incentives has often been the subject of discussion in the literature in various contexts, including performance, value elicitation, as well as risk aversion and discounting (Smith and Walker, 1993; Read et al., 2005). We review past work in an attempt to bring together findings from the experimental literature on payoff effects as well as findings from the environmental economics literature on hypothetical bias given the crossover in the relevance of these two strands of literature.

3.2.1 Payoff effect in risk aversion

A large body of literature is dedicated to understanding the impact of monetary incentives on risk tasks in laboratory experiments. Since risk aversion tasks measure preferences rather than performance, there is no way of assessing whether incentives improve performance other than to monitor differences between the two treatments or any deviation from *a priori* expectations of economic theory. Findings from such studies are mixed. Beattie and Loomes (1997) find no effect of incentives on risk aversion, while Grether and Plott (1979) and Edwards (1953) find evidence of more risk-seeking behavior in incentivised gambles. Battalio et al. (1990); Binswanger (1980); Hogarth and Einhorn (1990); Holt and Laury (2002) find the opposite effect, i.e. subjects are more risk averse when presented with an incentivized choice of gambles and Cubitt et al. (1998) only find evidence of increased risk aversion for complex multi-stage gambles. A review of 74 experiments comparing different levels of financial incentives also found no effect of financial incentives on mean performance but did note a reduction in variance and a reduction in presentation effects (Camerer and Hogarth, 1999).

Other studies have investigated different mechanisms that might eliminate the need for incentives using different ways to incentivise cognitive effort and truth telling. Jacquemet et al. (2013) use a solemn oath prior to the valuation being elicited from subjects and find that it outperforms both hypothetical and incentivised designs. Vossler and Evans (2009) find that in treatments where subjects perceive their decisions to be of consequence they are unable to find evidence of elicitation bias, compared to treatments where this is not the case which provide evidence of elicitation bias existing. Both these studies suggest that money incentives may only be one method of triggering salience in experiments. Shogren et al. (2001) point out that if bidders in an auction perceive the probability of winning to be small they become disengaged with the process and will bid insincerely. They therefore propose different auction structures to overcome this disengagement.

The more general debate about bias in hypothetical valuation experiments is very much ongoing. Hausman‘s 2012 paper (Hausman (2012)) provides a scathing assault on contingent valuation (CV) methodology, which is mostly rooted in his concern about

hypothetical bias. This is attributed to lack of familiarity with the good being valued which is a typical shortcoming of CV elicitation. He criticizes the fixes adoped to counter hypothetical bias, such as applying a deflator to elicited values or adjusting the framing of questions to increase saliency. This view is not shared by others, such as Carson (Carson (2012)) and Haab (Haab et al. (2013)) who believe CV is still a promising technique. Haab (Haab et al. (2013)) argue that the Hausman critique ignores the fact that the CV method is still in a state of development. Hypothetical studies remain in use in areas such as marketing, where private money is at stake, and are only severely questioned when it impacts public funds. Haab (Haab et al. (2013)) argue that research suggests that the characteristics of the studies determine the hypothetical bias to a large extent and that various survey mechanisms, such as 'cheap talk experimental design (where subjects are encouraged to treat the hypothetical scenario as real) or the use of oaths (promises to represent their true preferences) have been shown to be effective at reducing hypothetical bias. Carson (Carson (2012)) states that CV surveys remain a good alternative in situations where good and values that cannot be easily quantified. While most of the debate on the suitability to CV is in relation to their use in lawsuits for compensation following environmental damage the vast majority of CV studies feed into cost-benefit assessments to justify environmental improvement and preservation which would not be possible without the quantification of benefits (Carson (2012)).

Comparing different payoff structures (hypothetical vs. random-lottery payment vs fully paid experiment)[1] Beattie and Loomes (1997) found no evidence of an incentive effect in three of the four gambles they presented to subjects, something also noted by Davis and Holt (1993). The one gamble which exhibited significant differences had the unique characteristic of being a multi-stage gamble requiring increased cognitive effort on the part of subjects to internalise future scenarios, suggesting that the impact of incentives is task-specific. Camerer (1995) argued that effects of payments are task specific, with incentives in decisions under risk and uncertainty not improving subjects

[1]Random-lottery payment implies contexts where subjects perform multiple risk tasks with only one of them being randomly selected to be paid out, whereas fully paid experiments ask subjects to make one or multiple gamble choices and all outcomes are paid out in real money

behavior (i.e. bringing them closer to *a priori* expectations based on axioms of rationality), while Cubitt et al. (1998) similarly concluded that the effect of payoffs is not significant for simple tasks but may become more relevant for more complex ones.

3.2.2 Effect of incentives in discounting

The presence of a payoff effect in discounting experiments is less populated. Kirby and Marakovi (1995) suggest that discount rates elicited for real monetary payoffs are higher than those for hypothetical outcomes. These findings are initially mirrored in the findings of Coller and Williams (1999) but the conclusions are less clear once data issues are accounted for. There is no literature on payoff effects in environmental discounting, this will be the first experiment to test for them.

3.2.3 Hypothetical bias in valuations

Requiring subjects to make intertemporal decisions requires an inherent valuation of the presented outcomes. A large environmental and health literature has raised concerns over hypothetical bias[2] in willingness-to-pay (WTP) tasks. Loomis (2011) found that willingness to pay in hypothetical experiments can be larger that the actual value by a factor of 2 or 3. Hausman (2012) points out that the problem of hypothetical response bias is a primary cause for discrediting the entire methodology of contingent valuation[3]. While there are cases where hypothetical and incentivized valuations have appeared identical (Smith and Mansfield, 1998; Johannesson, 1997) most studies find that hypothetical valuations exceed actual values (List and Shogren, 1998; Fox et al., 1998; Cummings et al., 1995). A meta analysis of 29 experimental studies found that hypothetical valuations were larger than actual ones by a factor of 3 (List and Gallet,

[2]Hypothetical bias is termed as the discrepancy between stated/hypothetical and actual/incentivized WTP values, whether in between or within subject comparisons.

[3]This view has been endorsed by some such as Desvousges et al. (2016) but has been debated by others such as Haab et al. (2013)

2001), while a later meta-analysis of 28 stated preference valuation studies found differences by a factor of 2.60 (Murphy et al., 2005).

Looking at the determinants of hypothetical bias, List and Gallet (2001) highlight *familiarity of subjects with the question being posed* as the main driver of differences between hypothetical and incentivized valuations - which are perceived as *errors* made by subjects in conveying their true value. The issue of familiarity and certainty in ones responses is implicit in Johannesson (1997) who observes that eliciting subjects' confidence in their valuation and controlling for it mitigates the presence of hypothetical bias in the valuation exercise. Familiarity is also cited by Harrison and Rutström (2008) as the possible reason behind Smith and Mansfield (1998)'s lack of evidence of hypothetical bias.

3.3 Methodology

Risk and time preferences were elicited in a controlled lab experiment. This was done for two goods, money and environment, where money provided us with a comparable benchmark to previous literature. This is the first experiment to test for the incentive effect with environmental goods. The experiment was conducted over eight sessions, half with incentivized and half with hypothetical tasks. With the exception of the payoffs for the incentivized tasks the incetivized and hypothetical treatments were identical in all other ways (including both having a show up fee). Participants were randomized to a treatment (i.e. incentivised or hypothetical) and a good (i.e. money or environment) in a between-subjects design. Four experimental groups emerge from this setup. Group A completed the incentivized tasks with money, Group B the incentivized tasks with environment, Group C the hypothetical tasks with money and Group D the hypothetical tasks with environment. Once allocated to a group, a subject sequentially undertook a discounting and a risk aversion task. At the end of the experiment individual information on subjects cognitive reflection abilities, environmental attitudes and demographics was collected.

The choice of environmental good required it to be divisible so as to enable the incremental increase in the magnitude of the outcome for the risk and discounting task. In addition, it had to be one that was familiar to subjects and credible. Following Ioannou and Sadeh (2016), the good chosen was a locally-based project that distributed outdoor bee-friendly plants to staff and students at a UK university. Subjects were informed of the project in the experiment and told that different bee-friendly plants would be chosen depending on the season they are distributed to ensure that they are immediately beneficial.[4] The environmental project was described in a succinct and neutral manner.

The experimental sessions were conducted in the university's Social Sciences Experimental Lab and subjects were recruited from the university's student population using an electronic recruitment system. Subjects were allowed to participate in only one session. Each session had at most 16 subjects (the maximum lab capacity) and lasted approximately 45 minutes. The experiment was programmed and conducted using the z-Tree software (Fischbacher (2007)).

All subjects were given a £5 show up fee in cash following the completion of the experiment. In the incentivised treatment subjects were also given the opportunity to receive an additional payment. They were paid using a random-lottery payment mechanism for the monetary and environmental discounting and risk aversion tasks (Coller and Williams (1999), Harrison et al. (2002), Barreda-Tarrazona et al. (2011)). In addition a second layer of randomness was applied, where only one subject is paid for the risk aversion tasks and one subject is paid for the discounting tasks. We refer to this incentive compatible payment mechanism as a *double layered random payment mechanism* (Charness et al., 2016). There was no payment for the remaining tasks. The subjects of the hypothetical treatment were only paid their participation fee. This creates a difference in the expected payoff of the experiment for the two treatments. This is

[4]The magnitude of the choices in the monetary domain and the environmental domain were calibrated using two contingent valuation studies carried out at the university prior to the experiment. The mean willingness to pay for a plant was at £4.98. Consequently, a conversion rate of 1 plant = £5 was implemented. Subjects were therefore presented with choices starting at £50 in the monetary domain and 10 plants in the environmental domain.

a key difference between incentivised and hypothetical experiments. Hypothetical experiments rely on intrinsic motivation for subjects to correctly evaluate their preferences and perform tasks to the best of their ability. There should be no extra reward, including a higher show up fee, to impact this motivation. In contrast, incentivised experiments provide external motivation in the form of payoffs to create such incentives. Each of the sequential tasks administered are described in the paragraphs below.

3.3.1 Discounting

The Monetary Discounting and the Environmental Discounting tasks present subjects with repeated choices between a smaller sooner and a larger later outcome. The smaller sooner amount is kept fixed, whereas the larger later amount progressively increases in order to elicit the point at which subjects become indifferent between the two outcomes. This fixed sequence titration method is a popular elicitation method for intertemporal preferences (Andersen et al. (2008); Harrison and Lau (2005); Hardisty and Weber (2009)) and has been found to be the simplest method out of those that best predict real world outcomes (Hardisty et al. (2013)).

Subjects were presented with six progressively larger trade-offs for three different delay periods: (i) a 3-month delay period, (ii) a 6-month delay period, and (iii) a 12-month delay period. Thus, in total subjects had to respond to $6 \times 3 = 18$ binary questions for each of the monetary and the environmental domains (see Table 3.1 for exact amounts).

Table 3.1: DISCOUNTING TASKS

MONETARY DISCOUNTING		ENVIRONMENTAL DISCOUNTING	
Smaller sooner (£)	Larger later (£)	Smaller sooner (plants)	Larger later (plants)
50	55	10	11
50	60	10	12
50	65	10	13
50	70	10	14
50	75	10	15
50	100	10	20

Notes: The binary options presented to participants of the monetary discounting task are displayed in the first two columns. These are denominated in pounds. The binary options presented to participants of the environmental discounting task are displayed in the latter two columns. These are denominated in plants.

3.3.2 Risk Aversion

Risk preferences were captured through a variant of the Eckel-Grossman test (Eckel and Grossman (2002)), where subjects are presented with five gambles of varying riskiness and are required to select the one they prefer. All gambles have two possible eqi-probable outcomes, i.e. Outcome X with 50% likelihood and Outcome Y with 50% likelihood. In addition, the expected payoffs are easy to calculate and the increasing variance as the gambles get riskier is large enough to be noticeable.

Both the Monetary Risk Aversion Test and the Environmental Risk Aversion Test were calibrated at a magnitude level that is comparable to the choices given to subjects in the discounting tasks. The gambles offered started with a sure win, with an option

with identical outcomes (a gain of £50 / 10 plants) and moved to options of increasing variance at the point where the last option's equiprobable outcomes were £5 and £162.50 (or 1 plant and 33 plants). The conversion rate of money per plant used was £5 (see Table 3.2 for the gambles presented).

Table 3.2: RISK AVERSION TASKS

Panel A

Monetary Risk Aversion Test

Option	Outcome X		Outcome Y	
	Payoffs (£)	Probability (%)	Payoffs (£)	Probability (%)
1	50.00	50%	50.00	50%
2	35.00	50%	87.50	50%
3	25.00	50%	112.50	50%
4	15.00	50%	137.50	50%
5	5.00	50%	162.50	50%

Panel B

Environmental Risk Aversion Test

Option	Outcome X		Outcome Y	
	Payoffs (plants)	Probability (%)	Payoffs (plants)	Probability (%)
1	10 plants	50%	10 plants	50%
2	7 plants	50%	18 plants	50%
3	5 plants	50%	23 plants	50%
4	3 plants	50%	28 plants	50%
5	1 plant	50%	33 plants	50%

Notes: Panel A displays the options presented to participants of the monetary risk aversion task. Participants were presented with the five gambles presented here and were required to select their preferred gamble. Panel B displays the options presented to participants of the environmental risk aversion task. Participants were presented with the five gambles presented here and were required to select their preferred gamble. The magnitude of the gambles is calibrated to be of equivalent value, with the rounding up of payoffs occuring in the environment domain.

3.3.3 Other tasks

In addition to the core discounting and risk aversion tasks the experiment collected information on relevant individual characteristics to allow testing for heterogeneity of effects in the analysis.

Subjects were presented with the Cognitive Reflection test (CRT), is a measure of the individual's ability to suppress a spontaneous response in favor of a more deliberately-thought out one (i.e. subjects' reflective ability) (Frederick (2005); Taylor (2013); Benjamin et al. (2013)). The questions themselves require no special linguistic or mathematical skills.

An environmental questionnaire was administered in the penultimate stage in order to avoid any unintentional impact they might have on subjects' choices. Subjects are asked to express their level of agreement with 17 statements on a range of environmental issues and through their responses are classified into seven groups following DEFRA (2008). Following this, a valuation question[5] for a plant was included to elicit subjects' willingness-to-pay for the environmental good.

Finally, information on subjects' age, sex, monthly expenditure on non-accommodation expenses and ownership status of parents' home was collected.

3.3.4 Statistical Analysis

The effect of incentives on risk aversion and discounting choices is initially tested using χ^2, Mann-Whitney and Kolmogorov-Smirnov tests. Further, we fit regression models conditioning on experimental features and individual characteristics that might be influencing subjects' risk aversion and discounting choices. Both risk aversion and discounting tasks produce similar ordered categorical data so we discuss them in unison. Subject i's underlying preference is a latent variable $Y_i^* = x_i'\beta + e_i$ of which we only observe a discrete realization, Y_i, falling within thresholds, ξ_k. The probability that

[5]Payment card format with 6 interval bids: £0, £0.5, £2.5, £5, £10, £15, £15+

subject i selects response k is given by

$$Pr(Y_i = k) = Pr(\xi_{k-1} < Y_i^* \leq \xi_k) \quad \text{for} \quad k = 1...K \tag{3.3.1}$$

In the index function, x_i is vector of experimental or individual characteristics that influence responses/preferences and e_i is a random error term. Assuming a standard normally distributed error results in an ordinal data model with probability function

$$Pr(Y_i = k) = \Phi\left(\frac{\xi_{j+1} - x_i'\beta}{\sigma}\right) - \Phi\left(\frac{\xi_j - x_i'\beta}{\sigma}\right) \tag{3.3.2}$$

where, $\xi_0 = -\infty$ and $\xi_K = \infty$, $\Phi(.)$ is the standard normal cdf with $\Phi(-\infty) = 0$ and $\Phi(\infty) = 1$.

In the case of *risk data*, thresholds (ξ_k) are unknown and need to be estimated, which gives rise to the ordered probit model (McKelvey and Zavoina, 1975). Note that for identification purposes the variance of the model is normalized to one (i.e. $\sigma = 1$). For *discounting data*, thresholds are known (i.e. the experiment itself specifies such thresholds/cut-off points) and need not be estimated. This gives rise to the interval regression model where no normalization of the variance is required.

Following findings in past literature on the effect of incentives and other features on the variance, we partially relax the homoskedasticity assumption by parameterizing the variance and allowing for multiplicative heteroskedasticity, $\sigma^2 = \sigma^2 e^{z_i'\gamma}$ (Harvey, 1976).[6] [7] This allows us to examine how the mean, as well as the shape of the response distribution is affected by incentives.

In order to test the effect of incentives and other experimental features of our design

[6] This allows for a constant scale, σ, and multiplicative deviations according to individual characteristics, e.g. for a binary d we would have $\sigma = \sigma \cdot e^0 = s$ when $d = 0$ and $\sigma = \sigma \cdot e^\gamma$ when $d = 1$.

[7] In practice, to ease convergence we do not model σ but $ln\sigma$ and as such interpretation of the coefficients in the variance equation later on requires exponentiation.

we parameterise the index function of the model accordingly:

$$\begin{aligned} Y_i^* &= \beta_0 + \beta_1 Real_i + \beta_2 Good_i + \beta_3 (Real \times Good)_i \\ &+ \beta_4 Delay_i + \beta_5 Sex_i + \beta_6 MonthlyExp_i + \beta_7 OwnHome_i \\ &+ \beta_8 HighCRT_i + \beta_9 Green_i + \beta_{10} HighValue_i + e_i \end{aligned} \tag{3.3.3}$$

$Real$ is a dummy variable taking the value of 1 for observations from the incentivised treatments (and zero otherwise), $Good$ is a dummy taking the value of 1 for subjects who face environmental tasks (and zero otherwise), $Real \times Good$ is their interaction. For the *discounting data* (i.e. interval regression model) only, the index function includes a $Delay$ variable that represents the length of the delay (in months) that was presented to subjects (i.e. 3, 6, or 12 months). Sex takes the value 1 for females (0 otherwise), $MonthlyExp$ is an estimate of monthly expenditure on non-accommodation expenses, $OwnHome$ takes the value of 1 for subjects whose parents own their own home (0 otherwise), $HighCRT$ takes the value of 1 for those who scored high on the CRT test[8], $Green$ takes the value of 1 for those with positive environmental attitudes[9] and $HighValue$ takes the value of 1 for all subjects selecting the three highest value categories in the valuation exercise.

For the variance equation, multiplicative heteroskedasticity is modelled through z and includes $Real$, $Good$ and their interaction $Real \times Good$, which will allow us to assess the effect of incentives and domain on the variance.

3.4 Results

A total of 120 subjects participated over eight experimental sessn ions, 58 subjects saw the incentivised version and 62 subjects saw the hypothetical version of the experiment. Table 3.3 presents a comparison of the socio-demographic characteristics among the

[8] Answering at least two of the three CRT questions correctly.

[9] Segment groups 1 to 4 were classified as having positive environmental attitudes.

four groups. Overall, small variations are observed across groups with χ^2-tests suggesting no statistically significant differences.

Table 3.3: GROUP CHARACTERISTICS

Group	A	B	C	D	Total
Mean Age	20.8	20.6	20.0	19.8	20.2
Prop. Female	60%	44%	50%	56%	52%
Home Own.	80%	70%	83%	84%	80%
Monthly Exp.	£167.4	£257.0	£226.7	£232.2	£227.7
Valuation	4.93	3.09	4.25	3.91	4.07
CRT	1.77	1.63	1.83	1.53	1.69
# Subjects	31	27	30	32	120
Percent	26%	22%	25%	27%	100%

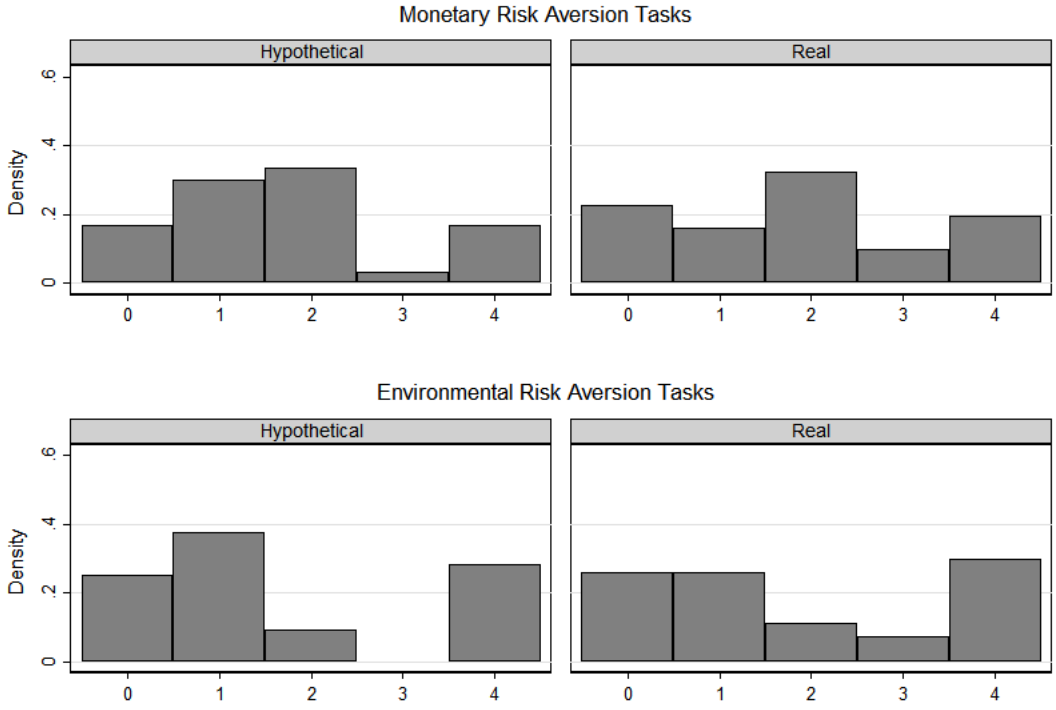
Notes: The $Total$ column presents mean values for the full sample. Kruskal-Wallis H tests assessing differences between the four groups in each of the characteristics found no statistically significant differences (result table reported in Appendix). The $Valuation$ values were obtained from an intercept-only interval regression on the value brackets yielding mean willingness-to-pay estimates. The values obtained are considered to be comparable to the £5 conversion rate adopted for the control of the magnitude effect in the experiment, therefore confirming that the monetary and environmental tasks were perceived to be of an equivalent magnitude by subjects.

3.4.1 Incentives in risk aversion tasks

Figure 3.1 presents histograms of raw responses in the risk aversion tasks with the two rows displaying money and environment goods, respectively. Moving from the hypothetical to the incentivized treatment, a drop in the probability of choosing the safer

gamble (gamble 1) and a subsequent increase in the probability of choosing the mid-point gamble (gamble 3) is observed for both goods (money and environment). This suggests incentives result in slightly risker gambles being selected. However, looking at the frequencies for the gambles chosen and formally testing for statistical differences (Table 3.4), we find no significant effect of incentives on risk aversion. Results are confirmed in ordered probit regressions of risk choices (Table 3.5) where again no effect of incentives on the mean or variance of expressed risk preferences is found when looking at both goods together or separately.

Figure 3.1: RISK AVERSION TASK CHOICES BY GOOD AND INCENTIVE TREATMENT



Notes: The x-axis displays the five gambles with the frequency that the gambles were chosen displayed on the y-axis. The gamble represented by 0 is the sure thing, while gamble 4 is the most risky gamble.

Table 3.4: RISK AVERSION

	MONETARY RISK		ENVIRONMENTAL RISK	
	Hypothetical (%)	Incentivised (%)	Hypothetical (%)	Incentivised (%)
0	16.7 %	22.6 %	25.0 %	25.9 %
1	30.0 %	16.1 %	37.5 %	25.9 %
2	33.3 %	32.3 %	9.4 %	11.1 %
3	3.3 %	9.7 %	0.0 %	7.4 %
4	16.7 %	19.4 %	28.1 %	29.6 %
Kolmogorov-Smirnov D		0.09		0.11
p-value		0.99		0.98

Notes: The table presents the percentage of subjects who selected each of the 5 gambles in the monetary risk aversion test in the hypothetical (column 2) and incentivised (column 3) treatments and for the environmental risk aversion test in the hypothetical (column 4) and incentivised (column 5) treatments. The bottom panel displays the result obtained from the Kolmogorov-Smirnov test based on the null of no difference between the risk aversion choices made in the incentivised and in the hypothetical treatments. Results confirmed under Pearson χ^2 and Mann-Whitney tests.

Table 3.5: ESTIMATION RESULTS FOR RISK AVERSION TASKS

	Both Goods	Money	Environment
	Group A, B, C & D	Group A & C	Group B & D
Mean			
Real	0.220	0.233	0.277
	(0.699)	(0.728)	(0.682)
Environment	-0.112		
	(0.610)		
Real × Env	0.0833		
	(1.089)		
Variance			
Real	0.0419	0.0227	0.470
	(0.370)	(0.413)	(0.376)
Environment	0.445		
	(0.331)		
Real × Env	0.141		
	(0.513)		
Subjects	102	44	58
Log likelihood	-144.06	-60.06	-78.52
BIC	366.74	169.28	209.82

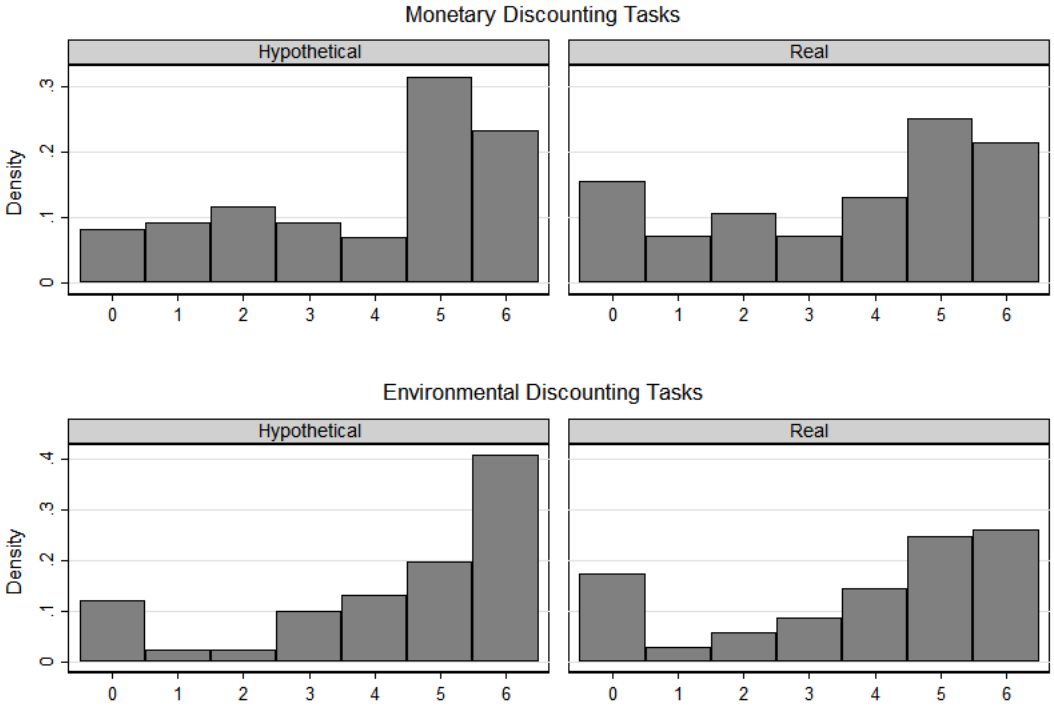
Notes: The results obtained from ordered probit regression models are displayed above. The results of the merged data for both goods is in column 1, while column 2 and 3 display the individual results for the two goods. All models control for all covariates but only present those necessary for interpretation of incentive effects. Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

3.4.2 Incentives in discounting tasks

Figure 3.2 presents the histograms of responses for the discounting tasks by treatment for money and environment.[10] For both goods, the frequency of high discount rates (switch points 5 and 6) drops once incentives are introduced, which can be seen as a shift to the left in the distribution. This effect reaches marginal statistical significance only for environment discounting (Table 3.6).

[10]Ninety two percent (i.e. 92%) of the subjects had one switching point in their discounting task. However, there were some instances where subjects alternated between smaller sooner and larger later choices in the payment ladder more than once. Seven subjects exhibited such behavior in more than one discounting task and are, hence, dropped from the dataset, as either unable to understand the task or wilfully uncooperative. In the remaining instances subjects were assumed to have made an error and the observations for this particular set of choices are removed while the rest of the observations for the individual are kept in dataset.

Figure 3.2: DISCOUNTING TASK CHOICES BY GOOD AND INCENTIVE TREATMENT



Notes: The x-axis displays the point at which the subject switched from the smaller sooner amount to the larger later amount. The frequency with which the switch was chosen is displayed on the y-axis. The switch at 0 represents the lowest discount rate, where the subject switched immediately on the first increment, while switch 6 represents subjects who were never enticed to wait even at the highest increment.

Table 3.6: DISCOUNTING

Switching Point	MONETARY DISCOUNTING		ENVIRONMENTAL DISCOUNTING	
	Hypothetical (%)	Incentivised (%)	Hypothetical (%)	Incentivised (%)
0	8.1 %	15.5 %	12.1 %	17.4 %
1	9.3 %	7.1 %	2.2 %	2.9 %
2	11.6 %	10.7 %	2.2 %	5.8 %
3	9.3 %	7.1 %	9.9 %	8.7 %
4	7.0 %	13.1 %	13.2 %	14.5 %
5	31.4 %	25.0 %	19.8 %	24.6 %
6	23.3 %	21.4 %	40.1 %	26.1 %
Kolmogorov-Smirnov D		0.08		0.15
p-value		0.90		0.33

Notes: The table lists the percentages of subjects who switched from the smaller sooner to the larger later in the monetary discounting task in the hypothetical and incentivised treatments (columns 2 and 3 respectively) and for the environmental discounting task in the hypothetical and incentivised treatments (columns 4 and 5 respectively). The bottom panel displays the result obtained from the Kolmogorov-Smirnov test based on the null of no difference between the discounting choices made in the incentivised and in the hypothetical treatments. Results confirmed under Pearson χ^2 and Mann-Whitney tests.

Looking at the incentive effect using interval regressions (Table 3.7) we find no evidence of an effect on the mean discount rate but find a significant effect for the vari-

ance.[11] Focusing on each good in isolation (Table 3.7), we confirm no effect on the mean and an increased variance for money tasks. For environment, incentives reduce the mean (i.e. lower average discount rates suggest more patience) and the variance (i.e. implying expressed discount rates are more concentrated around the mean).[12]

[11] As we model the logarithm of the variance as a function of interactions the effect on the variance of real incentives for environment would be calculated as $exp(\gamma_{Constant} + \gamma_{Real} + \gamma_{Good} + \gamma_{Real \times Good})$. In similar fashion, we can calculate the effect on the variance of hypothetical task and/or when money good is used.

[12] For purposes of reference we provide the range of discount rates elicited, even though the experiment was designed to compare changes in levels rather than the level itself. The lowest mean discount rate elicited was 143% for the incentivised environmental good, while the highest mean discount rate was 221% which was elicited for the hypothetical monetary good.

Table 3.7: ESTIMATION RESULTS FOR DISCOUNTING TASKS

	Both Goods	Money	Environment
	Group A, B, C & D	Group A & C	Group B & D
Mean			
Real	0.251	0.323	-0.851**
	(0.594)	(0.607)	(0.418)
Environment	0.667		
	(0.412)		
Real × Env	-1.036		
	(0.729)		
Constant	-0.601	-0.690	-0.563
	(1.588)	(1.900)	(2.340)
Variance			
Real	0.867**	0.929***	-0.552**
	(0.360)	(0.343)	(0.278)
Environment	0.978***		
	(0.248)		
Real × Env	-1.379***		
	(0.437)		
Constant	-0.266	-0.287*	0.672***
	(0.173)	(0.168)	(0.200)
Subjects	96	42	54
Log Pseudo-likelihood	-467.22	-191.96	-270.01
BIC	1030.30	446.49	605.83

Notes: The results obtained from interval regression models are displayed above. The results of the merged data for both goods is in column 1, while column 2 and 3 display the individual results for the two goods. All models control for all covariates but only present those necessary for interpretation of incentive effects. Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

3.5 Discussion

This study investigates the impact of incentives on monetary and environmental risk aversion and discounting tasks in an experimental setting. Overall, incentives would be expected to enhance saliency, encourage truthful elicitation of preferences and motivate sufficient cognitive effort.

A priori expectations are limited for risk aversion tasks, as economic intuition offers little guidance as to whether incentives would be expected to make subjects display increased or decreased risk aversion. Our evidence suggests that in simple risk aversion tasks incentives make no difference to reponses irrespective of the monetary or environmental context. This confirms previous work such as Camerer and Hogarth (1999) who also found financial incentives in money tasks had no effect on mean values and instead reduced variance in the case of complex gambles, as well as those from other non-strategic games (Mentzakis and Mestelman (2013)) who also report no incentive effects.

For discounting tasks, *a priori* expectation could suggest that real payoffs would heighten the dis-utility of waiting and results in higher discount rates for incentivised treatments (Kirby and Marakovi (1995); Coller and Williams (1999)). However our results indicate that in monetary discounting incentives increase the variance of responses (in a similar vein to Vandegrift and Brown (2003)) while in environmental discounting incentives reduce both the mean and variance of discount rates. Such incentive effects are in line with the contingent valuation literature and the commonly observed hypothetical bias (List and Gallet (2001); Murphy et al. (2005)). When playing with real incentives subjects appear to be more patient and willing to wait for larger environmental benefits. The implicit valuation required in environmental discounting tasks brings the underlying process closer to contingent valuation tasks and offers a natural explanation for the similarity in findings. Mean and variance effects could be driven by unfamiliarity with making decisions in an environmental domain which increase its cognitive difficulty.

The results of this research suggest that incentives have an impact on discount rate elicitation, in particular on the variance of responses. It appears that the strength of the impact is linked to familiarity and the implicit cognitive load of the task. The environmental discounting task was the most demanding due to the interaction of the hypothetical and unfamiliarity elements. When the hypothetical element was removed it decreased the cognitive effort needed resulting in lower mean discount rates and lower variability of discount rates elicited. In the case of money discounting, the more familiar environment, incentives were not required to counter the cognitive effort and we observe no change in the mean discount rate. Instead, we observe an increased variance in money discounting choices which can be attributed to subjects moving away from switching in the middle of the distribution and instead aligning themselves with either a patient profile or an immediate gratification at all costs profile thereby increasing the variance.

The link between cognitive effort required and incentives supports the findings summarised in Camerer and Hogarth (1999). Incentives appear to be the counterweight to the cognitive burden that subjects bear in experiments. This research suggests that the decision to incentivise an experiment should be directly linked to the cognitive difficulty of the experiment. It also supports the claim that in many simple tasks with no role for untruthful representation incentives may be superfluous.

In noting the limitations to this study, like any economic experiment, the findings should be confirmed using a more representative sample. Given the sensitivity of time and risk preferences to the many dimensions of choice findings cannot be easily generalised to goods that are of a different nature, or size to the ones used in this experiment. It would be useful for future research to test whether the findings hold under different specifications of environmental instrument. It would be interesting for future research to incorporate different levels of cognitive effort in a more explicit way to test the impact of this on performance under different incentivisation schemes.

Overall, we provide evidence of a heterogeneous but significant effect for incentives. These findings are preliminary in nature and require further investigation to un-

derstand the dynamics at play. Cognitively demanding and strategic games seem to be more prone to discrepancies between hypothetical and incentivized treatments and might benefit from incentives in convincing subjects to expend the increased cognitive effort required. Further, hypothetical discounting studies should be used with caution in the case of non-monetary goods (i.e. environment, health etc.).

The findings suggest that eliciting time preferences using the traditional titration method for goods that are hard to incentivise in a lab. It raises important experimental design questions for researchers working in the environmental and health economics fields. A suggested way to decrease the effect of cognitive load on participants in these cases would be to increase familiarity and understanding of the good being traded. This may serve to counter the inability to incentivise effort using payment. Additionally, experimenters may want to test for cognitive load, using, for example, work tasks along the experiment to test attention, or using consistency checks to confirm attention. Future research should aim to explore the external validity of these tasks and replicate past findings with real incentives before assessing methodological aspects.

4

Multi-Attribute Elicitation of Time Preference

4.1 Introduction

Discount rates reflect the preference of individuals for positive outcomes to occur sooner rather than later. This is formally referred to as *time preference* and is a reflection of the behavioural trait of impatience. Economists and policy makers use discount rates in many ways, they are incorporated into models of the economy and of decision making, they are also used in policy and project evaluation. In all these cases discount rates are used in order to assign a lower weight to outcomes that occur in the future.

Economists have been eliciting discount rates in lab experiments in order to study intertemporal decision making. The typical method of elicitation involves presenting subjects with discrete choices between two outcomes, a smaller outcome that occurs with no (or a very small) delay (**smaller sooner**) and a larger outcome that subjects receive with a delay (**larger later**). The discount rate is elicited by attempting to find

the subject's point of indifference between the two outcomes. This would indicate that the utility from the smaller sooner is equal to the utility from the larger later and by equating these outcomes one can calculate the discount rate.

The current model of discounted utility, based on the work of Samuelson (1937) while praised for its simplicity has been found to be a poor descriptor of the decision making process individuals undertake when comparing outcomes across time. Economists have identified a number of *anomalies*, or deviations from this model, when eliciting discount rates in experimental settings. The approach that researchers take to investigate these *anomalies* is to focus on one of them at a time in order to understand how they impact the intertemporal decision making process in a standard *between subjects* set up, keeping the rest constant. The research into identifying *anomalies* has cemented them into the mainstream of the literature on discounting and has raised interesting questions about the current representation of utility and the need for a more nuanced way of modeling utility. It is clear that what we still refer to as *anomalies* are actually **dimensions of discounting**, that are not exceptions to a rational model of discounting but rather integral parts of the decision making process that have been omitted from the model. There is, however, little known about how these *anomalies* affect each other, and how they interact with each other. This is a serious obstacle to researchers attempting to put together a comprehensive discounting model that incorporates these various dimensions of discounting.

This paper will elicit discount rates while simultaneously varying a number of *anomalies* in order to begin to fill this gap in the research. We do this by using a *discrete choice experiment* (DCE) set up where subjects are repeatedly presented with binary scenarios where a number of characteristics of the scenarios change, one of which is time delay. This is in distinct contrast to the *ceteris paribus* environment typically used in discounting experiments. DCEs are an established methodology in the fields of environmental and health economics. This methodology is an ideal tool for this as it allows for the varying of as many attributes, or characteristics, as needed. The methodology also estimates the marginal contribution to utility of each attribute that we present subjects with, thereby allowing for the isolation of the effect of time preference and any other *anomaly*

elicited.

Discrete choice experiments have been used sparsely in intertemporal choice literature before, but never for the investigation of multiple *anomalies*. Van der Pol and Cairns (2001) use a DCE set up to elicit discount rates in a *ceteris paribus* environment, in a similar fashion to traditional smaller sooner-larger later set ups. Viscusi et al. (2008) incorporate a time delay element into a traditional DCE set up for the valuation of an environmental good. This paper only looks at the impact of time delay independently of any other discounting dimensions.

This paper attempts to answer the following question: do the *anomalies* affect the interteporal decision making process concurrently but separately or do they interact with each other in order to amplify or weaken their individual effects? This will be the first study to elicit discount rates while simultaneously varying three separate discounting dimensions (or *anomalies*).

We find highly significant interactions between all the *anomalies* suggesting that the impact of each one depends on the levels of the others. This highlights the need to elicit such *anomalies* simultaneously. Finally we are able to extract the discount rates for each scenario analysed and find that the discount rates corroborate previous findings in literature, discount rates for small magnitudes are larger than those for large magnitudes, the annual discount rate for longer delays is smaller than that for shorter delays and discount rates for health outcomes are generally higher than those for environmental outcomes. We elicit conservative[1] discount rates of between 14-60%.

The next section provides a brief overview of the literature on discounting *anomalies* and the literature on the use of DCEs in discount rate elicitation. Section 4.3 describes the DCE methodology and experimental design used and Section 4.4 presents the results on the experiment. Finally Section 4.5 concludes the paper by discussing the relevance of the findings and the scope for future research.

[1]Conservative in comparison to the wide range of discount rates elicited in previous literature as discussed in Frederick et al. (2002) which range from 1% to figures in the double-digit thousands.

4.2 Literature

The fact that discounting behaviour seems to deviate from the expectation of economic theory in almost every way imaginable has led to a large body of literature investigating every dimension of these digressions. In the literature they are referred to as *anomalies*, or deviations from constant discounting. These *anomalies* are well documented and expertly summarized in Frederick et al. (2002), Loewenstein and Prelec (1992) and Read (2003). The most prominent ones include the notion of time inconsistency (also referred to as hyperbolic discounting), where individuals have a steeply declining rate of time preference which is magnified the closer the temporal trade-off gets to the present (Laibson (1997); Green and Myerson (1996)); the magnitude effect, where large outcomes are discounted less than smaller ones (Chapman and Elstein (1995); Green et al. (1997)); the sign effect, where gains are discounted more than losses (Thaler (1981)); the sequence effect, where individuals prefer constant or increasing sequences to decreasing ones (Chapman (1996a); Loewenstein and Prelec (1993)); the interval (or delay) effect, where higher discount rates are obtained (per time unit) for shorter delays than for longer ones (Read et al. (2005)) and the domain effect, where different goods are not only valued differently but also discounted differently (Cairns (1992); Chapman and Elstein (1995); Madden et al. (1999); Hardisty and Weber (2009)). This list is not exhaustive, and as the body of research on discounting grows, so does the refinement of these effects into sub-effects and the number of theories attempting to create some order out of all these findings.

Economists and psychologists have been asking subjects (or participants - depending on the discipline) to reveal their individual rates of time preference by presenting them with two outcomes, a smaller outcome which is realised in a sooner time period and larger outcome that will only be realised at a later time period. In the experiment the smaller sooner outcome is usually kept fixed while the larger later outcome is varied; typically starting from a small increment that would not induce any desire to wait for the larger outcome and then progressively increasing in order to elicit a *switching point*. This is when the subject is induced to switch from selecting the smaller sooner outcome

to choosing the larger later one and it occurs when the larger later outcome is sufficiently large to overcome the disutility of waiting. This switching point allows experimenters to identify the subject's indifference point between the two outcomes. This point of indifference represents the point where the utility derived from the two outcomes is equal and therefore setting the outcomes equal to each other allows for the calculation of the rate that equates them, which is the discount rate.

This traditional elicitation format has the limitation of only being able to vary one dimension, the outcome, while keeping all the *anomaly* levels constant. In order to investigate discounting *anomalies* experimenters use a between subjects design to test each *anomaly* against a baseline scenario, making the examination of combinations of *anomalies* cumbersome. In addition, this traditional elicitation format has been criticised for placing too much emphasis on delay and thereby highlighting the disutility it generates thereby inflating discount rates elicited (Cubitt et al. (2017)).

In their scientific review of the research on time preference Frederick et al. (2002) highlight the need to move away from a one-parameter discount rate to one that incorporates multiple discounting dimensions. There have been attempts to remove discounting from the traditional *ceteris paribus* environment. Some authors have taken a multi-dimensional approach to discounting, modeling choice within multi-attribute structures that allow for greater number of influences on time preference. Cubitt et al. (2017) look at discounting choices in a more complex decision environment by distinguishing between the traditional smaller-sooner/larger-later choices on the same good (uni-modal choice) and the idea of looking at discounting using a cross-modal choice where subjects are presented with a choice between two different outcomes, with one occurring with a delay. Scholten and Read (2010) discuss how the observed *anomalies* imply that a fully attribute-based model is the only way to incorporate observed discounting behaviour and develop a tradeoff-model to accommodate discounting *anomalies*. The above research focuses on one or two discounting dimensions. Research still has not been carried out that focuses on incorporating simultaneous estimation of multiple discounting *anomalies* with the aim of investigating how they influence each other.

In order to do this we adapt a standard valuation tool that is the workhorse methodology in the fields of environmental and health economics. Discrete choice experiments (DCE) were initially developed by Louviere and Hensher (1982) and Louviere and Woodworth (1983). This methodology has established itself as a popular stated preference method for the valuation of non-market goods. It is based on the premise that the individual component or *attributes* that make up an outcome each contribute to the overall utility derived from that outcome, and that this total utility can be broken down into the individual contributions to utility of these attributes. As DCEs are based on this modular structure, where the whole is broken down into individual parts, they prove to be an ideological fit to the elicitation of discount rates while varying multiple *anomalies* as outlined above.

There have been few papers that have used DCEs in the field of discounting. Van der Pol and Cairns (2001) are the first to put the methodology to work in an exercise to elicit time preferences for health outcomes. They incorporate the traditional smaller-sooner / larger-later design into a DCE set up and estimate the resulting discount rates using the random utility model which is the model underpinning the DCE methodology. They elicit discount rates ranging from 0.055 to 0.091 for own health and 0.078 to 0.147 for others' health. Van der Pol and Cairns (2001) conclude that the DCE methodology provides comparable estimates of discount rates for ill-health that are comparable to those elicited in standard experimental set up and suggest it might be even more successful for use in a financial context which might be easier for respondents to evaluate the scenarios provided. Asenso-Boadi et al. (2008) carry out a meta analysis of health discounting papers and conclude that the chosen data collection method did not seem to influence discount rates elicited.

A second application of the DCE methodology to discounting is carried out by Viscusi et al. (2008) who elicit discount rates by extending the typical DCE valuation set to include a time attribute in their study valuing water quality improvements. They postpone the start of the environmental project they describe by 2, 4 and 6 years in order to elicit a marginal effect of the delay, which is interpreted as the impact on utility of delaying the outcome. They highlight the advantage that the DCE methodology provides

which allows them to estimate discount rates within the context of utility rather than by making assumptions on the relationship between monetary (or other) payoffs and the utility they convey.

Although the number of papers that apply DCE methodology to disocunting are few, they suggest that this methodology may be a good fit for investigating the role that *anomalies* play in determining the intertemporal preferences of individuals. In addition, the flexibility it brings allows for the simultaneous elicitation of these *anomalies* and therefore is the ideal set up for the multi-attribute elicitation of discount rates.

4.3 Experimental Methodology

Since the seminal work by Louviere and Hensher (1982) and Louviere and Woodworth (1983) Discrete Choice Experiments (DCEs) have been used by environmental and health economists in order to obtain willingness to pay estimates for environmental and health outcomes (Hanley et al. (1998); Rose et al. (2008); de Bekker-Grob et al. (2012)). The underlying concept is that the utility we obtain from a good is a composite utility made up of the separate contributions to utility of the characteristics of the good. In the terminology of DCE these various characteristics of the good are called attributes. In this framework attributes are the sources of utility that combine to make up the total utility derived from the good. The contribution of a specific attribute to overall utility is a part worth. The attributes can take a small number of specified values or levels. The random utility framework is at the core of the theory behind DCEs. The following is an exposition of the framework based on Hensher et al. (2005).

U_i is the utility of alternative i. V_i is the part of this utility that is observed by the analyst, the representative component of utility, and ϵ_i is the part that remains unobserved. When we assume that these two components are independent and additive we can express utility as:

$$U_i = V_i + \epsilon_i \tag{4.3.1}$$

We can represent V_i using the set of attributes that impact utility.

$$V_i = \beta_{0i} + \beta_{1i} f(X_{1i}) + \beta_{2i} f(X_{2i}) + ... + \beta_{Ki} f(X_{Ki}) \tag{4.3.2}$$

where β_{Ki} is the parameter associated with attribute X_{Ki} and β_{0i} is the parameter that represents the role of all unobserved sources of utility (on average). It is not associated with any of the observed and measured attributes and therefore called the alternative-specific constant.

The underlying behavioural rule behind a DCE, assuming an individual acts rationally, is that they are assumed to compare alternatives and to choose the one that gives them the greatest utility. This rational choice of choosing option i can be stated as:

$$Prob_i = Prob[(U_i \geq U_j) \quad \forall \quad j \in j = 1, ...J; \quad i \neq j] \tag{4.3.3}$$

$$Prob_i = Prob[(V_i + \epsilon_i) \geq (V_j + \epsilon_j) \quad \forall \quad j \in j = 1, ...J; \quad i \neq j] \tag{4.3.4}$$

This is dependent on the unobserved component ϵ which is why it is a *random* utility maximisation rule. The principal advantage of this method is that anything constant or fixed between alternatives in a choice set drops out of the analysis, as it is assumed that it cannot have an influence in the choice if it impacts all the options equally. This property simplifies the analysis of the choices made.

We need to establish a relationship between the observed attributes and the observed choice outcome, while specifying a distribution for the unobserved error term. The unknowns are the weights attached to the attributes and the information in the random components. There are different models that attempt to do this. The conditional logit model (McFadden (1973)) is often used in discrete choice analysis.

$$Prob_i = \frac{expV_i}{\sum_{j=1}^{J} expV_j}; \quad j = 1, ..., i, ..., J \quad i \neq j \tag{4.3.5}$$

The probability of an individual choosing alternative i out of the set of J alternatives is equal to the ratio of the exponential of the observed utility index for alternative i to the sum of the exponentials of the observed utility indices for all J alternatives, including the ith alternative.

An alternative model, the mixed logit model, provides a more flexible approach that allows for the possibility of the presence of heterogeneity in the preferences of subjects. The mixed logit model relaxes the assumption that the error terms in the underlying model are IID and addresses violations of the IIA assumption in conditional logit models. In addition it also removes the need to assume that all subjects have the same preferences by allowing coefficients in the model to vary across subjects (Hensher and Greene (2003), Hole (2007)).

The utility model now becomes:

$$U_{iq} = \beta_q^{'} X_{iq} + [\eta_{iq} + \epsilon_{iq}] \tag{4.3.6}$$

In essence it transforms the utility function by separating the stochastic element ϵ into two parts. Once part (η_{iq}) is allowed to be correlated over alternatives while the second part (ϵ_{iq}) maintains the assumption of being IID over alternatives and individuals (Hensher and Greene (2003)).

4.3.1 Experimental Design

A DCE allows us to break down the contributions of each of the attributes to the overall utility. We can apply the same concept to eliciting time preferences. Looking at time preference in the light of DCE methodology the utility for a delayed choice can be expressed as a function of the numerous *anomalies* or dimensions of discounting. The literature on discounting anomalies allows us to identify the attributes that influence intertemporal choice.

The attributes included in this experiment include the following discounting *anoma-*

lies: Delay (discount rates elicited longer delays are proportionally smaller than those elicited for short ones), Magnitude (discount rates elicited for large amounts are proportionally smaller than those elicited for small ones) and Domain (discount rates elicited depend on the type of good being discounted). These attributes have been chosen because they are the most well-documented *anomalies* in discounting literature and they are well suited for incorporation into a DCE structure. Other *anomalies*, like gains vs losses, are harder to implement in a set up which requires a coherent scenario with simple departures from a baseline. This is not to say a DCE is not suitable to elicit them, but rather they require an additional level of innovation in design that was not attempted in this paper. In addition, the reason this paper limits itself to three anomalies with limited number of levels is due to cost and time considerations.

In this DCE the subjects are sequentially presented with a number of choice sets, or binary scenario comparisons. From each choice set they must select one out of the two possible alternatives that they are presented with. The alternatives will describe two hypothetical projects which can be financed using public funds. Subjects are told there are only enough funds to finance one project. In each case the project involves a delayed outcome. Each choice set will contain all the attributes available (Delay, Magnitude and Domain). The alternatives will vary by the level of attributes presented to subjects.

In addition we introduce the attribute $Outcome$ in order to capture the trade-off needed to elicit discount rates. This allows us to describe the project in terms of an improvement on a current baseline. The $Outcome$ variable is a percentage of improvement that is then translated into the different magnitudes, different domains and is realised with different delays.

Each attribute is represented in the experiment by a few selected attribute levels. Two levels for Magnitude are chosen, a relatively low level of 100 and a larger level of 750. These levels are chosen as they span a large range of magnitude and translate into scenarios that are distinct and able to be distinguished in the eyes of subjects. Two domains are selected, the health and the environmental domain, as these are the two most researched domains outside of money and this allows us to make comparisons to

the literature. The delays chosen are 1, 2 and 5 year delays. These are typically considered to be short term (1 year) and medium term (2 and 5) in the literature. Since many discounting experiments are incentivised longer time spans are not often investigated. The improvement in outcome is set at a 10% and a 50% level in order to create improvements that were perceivably different for subjects. The levels of the attributes presented in the experiment are displayed in Table 4.1 below.

Table 4.1: ATTRIBUTE LEVELS USED

Magnitude [M]	100	750	
Domain [N]	Environment	Health	
Delay [D]	1 year	2 years	5 years
Outcome [O]	10%	50%	

Notes: The four attributes selected for this experiment are presented in the first column. The remaining columns display the attribute levels presented for each attribute. These levels then fed into the scenario design that the subjects were presented with.

Subjects are presented with repeated binary choices between Alternative A and B, where these alternatives will contain the attribute levels outlined above. This results in 24 choice sets, which are presented in 4.2 below. The choice combinations for Alternative A were created by taking every possible combination, **full factorial** of the attribute levels. These alternatives were then copied to create the combinations for Alternative B and matched to a combination from Alternative A. The matching was done randomly with a qualification that any choice sets where one alternative dominated the other was rematched. Random matching is not the most efficient method for creating choice sets, it was chosen because it allowed us greater control to ensure that the choice sets presented were not dominated. Since all the combinations used for Alternative A are presented to subjects efficiency plays a smaller role than in other designs.

Table 4.2: CHOICE SETS

Alternative	A				B			
Choice set	[O]	[M]	[D]	[N]	[O]	[M]	[D]	[N]
1	10%	750	2	Env	50%	750	5	Env
2	50%	750	5	Env	50%	100	2	Env
3	10%	750	5	Env	50%	100	1	Health
4	50%	100	5	Health	10%	100	1	Health
5	50%	100	1	Health	50%	100	1	Env
6	10%	100	1	Health	50%	100	5	Env
7	50%	100	1	Env	10%	100	5	Health
8	50%	750	2	Env	10%	750	1	Health
9	10%	100	2	Env	10%	750	5	Health
10	50%	750	5	Health	50%	750	2	Env
11	50%	750	1	Health	10%	750	1	Env
12	10%	100	5	Health	10%	750	5	Env
13	50%	100	5	Env	10%	100	2	Env
14	10%	750	5	Health	10%	100	1	Env
15	50%	750	2	Health	50%	750	1	Env
16	10%	100	1	Env	50%	100	2	Health
17	50%	100	2	Env	50%	750	2	Health
18	10%	750	1	Env	10%	750	2	Health
19	10%	750	1	Health	10%	750	2	Env
20	10%	100	5	Env	10%	100	2	Health
21	10%	750	2	Health	50%	750	5	Health
22	10%	100	2	Health	50%	100	5	Health
23	50%	750	1	Env	50%	750	1	Health
24	50%	100	2	Health	10%	100	5	Env

Notes: The table displays the 24 choice sets presented to all subjects. Columns 2-5 display the attribute levels for Alternative A, columns 6-9 display the attribute levels for Alternative B in each choice set. Where [O] represents the increased outcome needed to elicit a discount rate, [M] represents the magnitude, [D] represents the delay or waiting period, in years and [N] represents the domain, i.e. whether it is a health or environment good.

Each subject is presented with the full set of 24 choice sets outlined in Table 4.2, which means that all respondents completed all the choice tasks. In addition we repeat choice set number 7 as a consistency check within the experiment. So the total number of choice sets presented to each subject is 25. The order these choice sets are displayed in is randomly selected by the survey platform and each subject is presented with the choice sets in a different random order. The text used in the experiment to explain these choices and the attributes used is presented in the Appendix.

In order to create hypothetical scenarios that are meaningful to subjects we incorporate the attribute levels into a description of a health and environment scenario. We specify a baseline situation in both cases, a status quo of health outcome and a status quo of environment outcome. We then describe the improvement to the baseline scenario in the health/environment as the positive outcome of a local government policy that will play out for a specific time period. Once this time period of enjoying this outcome has passed the situation returns to the original status quo. This health/environment improvement changes between alternatives and choice sets and is composed of the attribute levels specified in Table 4.2. We make a choice to incorporate the magnitude attribute and the outcome attribute into one description in the scenario in order to simplify the textual description of the outcome. We therefore combine the outcome (the 10% or the 50% improvement referred to in) and the two different magnitudes (100 or 750) into four potential policy choices, a 10% $\times$ 100 improvement, a 10% $\times$ 750 improvement, a 50% $\times$ 100 improvement or a 50% $\times$ 750. These changes in the health and environment status quo were displayed in the scenario as weeks of improvement, therefore the four possible combinations of outcome and delay translated into 16 weeks, 21 weeks, 118 weeks and 161 weeks of improvement.

It might be hard for readers to understand what the outcome variable actually represents and the implications of this experimental design choice. If this experiment were run with money as the good in question, the outcome would represent the monetary reward that the subject is being offered. In eliciting discount rates we need to compensate subjects for waiting for the delay and therefore choices must intrinsically contain an outcome that is not fixed. In the standard elicitation method we would present subjects

with £50 today or £60 in 6 months. These two pound values £50 and £60 are the outcome attribute. If we wanted to add the magnitude attribute to this experiment we would have to present subjects with a small magnitude and a large magnitude. Hypothetically this could be £50 and £60 vs. £500 and £600. This is what is captured by the magnitude attribute. When presented with the monetary equivalent one can see clearly why the incorporation of outcome and magnitude is a natural experimental choice to make. This incorporation may raise questions about our ability to elicit the two separate attributes. We argue that in the monetary equivalent we would be eliciting both these elements and in a parallel way in our experimental design we do the same.

Given the random utility model that is the foundation for the DCE, the utility of the choice sets presented to subjects is therefore assumed to be a function of the magnitude of the outcome, the domain of the outcome, and the delay involved in receiving the outcome. We can extend equation 4.3.5 to include these attributes and parameterise V_i. This allows us to estimate the regression model outlined in equation 4.3.7 where; O=outcome, D=delay, M=magnitude and N=domain.

$$\begin{aligned} V_i = \beta_{1i}O_i + \beta_{2i}D_i + \beta_{3i}M_i + \beta_{4i}N_i + \textit{(main effects)} \\ +\beta_{5i}O_i * D_{2i} + \beta_{6i}O_i * D_{5i}\textit{(discount rate elicitation)} \end{aligned} \tag{4.3.7}$$

We also run a quadratic version of the model (equation 4.3.8), in line with that carried out by Viscusi et al. (2008). This allows the interacted variable to take on a non-linear form and replicates the flexibility displayed by the hyperbolic specification of the discount function.

$$\begin{aligned} V_i = \beta_{1i}O_i + \beta_{2i}D_i + \beta_{3i}M_i + \beta_{4i}N_i + \textit{(main effects)} \\ +\beta_{5i}O_i * D_i + \beta_{6i}O_i * D_i^2\textit{(discount rate elicitation)} \end{aligned} \tag{4.3.8}$$

In addition to estimating a model with main effects and an interaction variable to

capture the effect of a delayed outcome, the joint elicitation of the *anomalies* allows for the estimation of a fully interacted model which will allow us to look at the influence *anomalies* have on each other. This is represented by the equation 4.3.9 below. A note on model identification of this model can be found in Appendix 4.

$$
\begin{aligned}
&\textit{(main effects)} \\
V_i = \beta_{1i}O_i + \beta_{2i}D_{1i} + \beta_{3i}M_{1i} + \beta_{4i}N_{1i} \\
&\textit{(two-way interactions)} \\
+\beta_{5i}O_i * D_i + \beta_{6i}O_i * M_i \\
+\beta_{7i}O_i * N_i + \beta_{8i}M_i * N_i \\
+\beta_{9i}D_i * M_i + \beta_{10i}D_i * N_i \\
&\textit{(three-way interactions)} \\
+\beta_{11i}O_i * D_i * M_i \\
+\beta_{12i}O_i * D_i * N_i \\
+\beta_{13i}D_i * M_i * N_i \\
+\beta_{14i}O_i * M_i * N_i \\
&\textit{(four-way interactions)} \\
+\beta_{15i}O_i * D_i * M_i * N_i
\end{aligned}
\tag{4.3.9}
$$

4.3.2 Experimental Procedure

The experiment itself is divided into two parts. Part 1 is a Calibration Exercise and Part 2 is the Discrete Choice Experiment. The calibration exercise is carried out in order for the valuation of the two projects, in the health and environment domains, to match at a base level in the subjects perception. This calibration exercise presents the same two hypothetical scenarios to be used in the DCE and asks subjects to match their value by allocating the number of individuals to benefit from each project. The question

presented to subjects can be found in the Appendix.

The findings in the Chapter 3 of this thesis indicate that subjects performing hypothetical discounting tasks with environmental goods face a higher cognitive burden and may display higher variance and mean in responding. Following these findings it is noted that the calibration exercise being undertaken here allows subjects to begin to familiarise themselves with the two hypothetical projects. Familiarity was noted as being one of the ways to improve the outcomes of more complex hypothetical experiments.

The same subjects are invited to participate in Part 2 a week after completing Part 1. The resulting calibration from Part 1 feeds into the levels of the outcome that subjects will be exposed to in Part 2 of the experiment. Subjects were invited to participate in 11 versions of Part 2 of the experiment, depending on the calibration they exhibited in the Part 1 calibration exercise. Each of the 11 versions was calibrated to capture a mid-point of a calibration bracket that spanned a 20 individual trade-off between the health and environmental projects. Each subject was therefore presented with a Part 2 experiment that was tailored to approximately their personal calibration of the two projects.

While it was not the original purpose of the calibration exercise, a side benefit of the Part 1 calibration was the familiarisation of subjects with the hypothetical scenario used in the main DCE experiment (Part 2). There is evidence that this leads to stability of preferences and therefore more reliable estimates of true preferences (List and Gallet (2001)).

A pilot of the DCE was carried out prior to the experiment being carried out using a sample of 20 colleagues and acquaintances without an economics background to test the scenario clarity and credibility. Feedback sessions following the pilot fed into the final version of the text used in the experiment.

The hypothetical discrete choice experiment was administered online. The use of online experiments has increased in popularity in the field of economics due to the lower budget constraint and increased speed of administration as well as the ability to reach a wider and more diverse pool of participants. In fact many lab experiments can just as easily be administered online, Horton et al. (2011) find consistent results when lab

experiments are compared to those carried out using online labour markets. They also argue that online experiments are less likely to suffer from experimenter effects and other biases that arise from subjects being aware they are participating in an economic experiment and interacting with the wider group of participants (e.g. knowing there are buyers and sellers and knowing what role they are playing in the larger game). Bainbridge (2007) argues that apart from the more mundane advantages, online experiments are a tool that can enhance our reach as social researchers. He highlights the many advantages of using online experiments and suggests that this is a tool that has the potential to help social, behavioural and economic sciences to achieve substantial scientific advances. The research participants were recruited through Prolific Academic who nurture a database of reliable participants, allow for the rejection of unsatisfactory submissions and provide the option of selecting naive or experienced participants. They also screen for multiple submission and for respondents that provide partially complete experiments or that take substantially longer (or shorter) than expected to complete the experiment. The absence of the experimenter to answer questions was mitigated by providing clear instructions and an email address that could be used to make clarifications.

4.3.3 Research Objective

Based upon the literature on discounting *anomalies* this paper looks to address the following research question:

To examine whether discounting *anomalies* are interdependent and influence the intertemporal decision making process in a joint manner. To test whether the effect of discounting *anomalies* varies depending on the levels of other discounting *anomalies* that are implicitly or explicitly contained in the experimental design.

4.4 Results

4.4.1 Part 1: Calibration Exercise

The calibration exercise was carried out in the first week of September 2017, the sample consisted of 286 people recruited through the Prolific Academic research database, the experiment was hosted by online survey host SurveyMonkey. The responses to the online experiment were collected in a matter of hours. Most subjects completed the experiment in the estimated 5 minutes, with the average time taken at just under 4 minutes.[2] In addition to the data collected Prolific Academic also provides a large number of socio-demographic details for each subject which are analysed below to provide a clearer picture of the subjects.

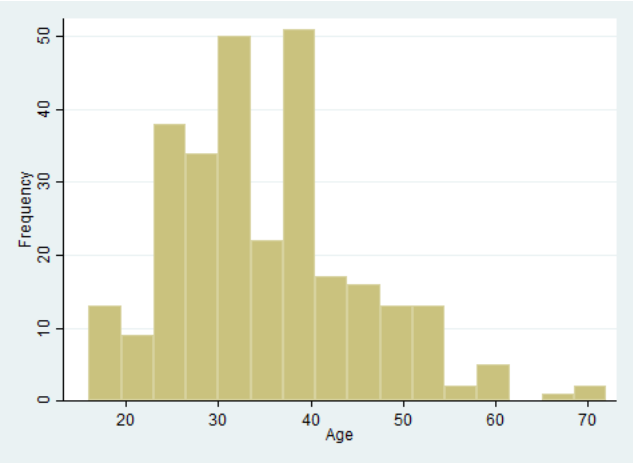
Descriptive Statistics

There is a balance of female and male subjects, with a total of 144 (50.3%) male and 142 (49.7%) female subjects. There is a wide representation of respondents from different age groups as can be seen from Figure 4.1. A large proportion of respondents have children and only 14% of respondents are students. There is encouraging diversity of experiences when it comes to health issues, which may have an impact on how respondents interact with the health policy. There is also a good mix of support for environmental issues such as the use of windfarms which may have an impact on how respondents interact with the environment policy.[3]

[2] This time is measured after they have been exposed to the hypothetical scenario and reflects the time taken to answer the calibration question.

[3] The questions posed by Prolific Academic are displayed in the Appendix.

Figure 4.1: FREQUENCY OF AGE OF SUBJECTS



Notes: The x-axis displays the age of respondents with the frequency displayed on the y-axis for Part 1 of the experiment.

Table 4.3: OTHER DESCRIPTIVE STATISTICS

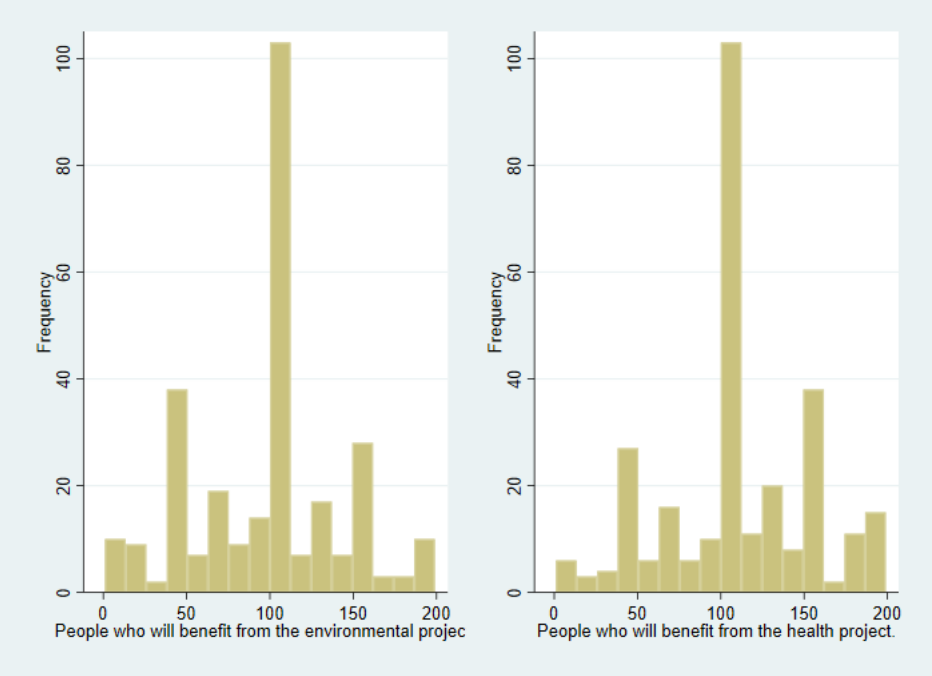
Variable	Yes	No	Rather not say	Total
Children	158	127	1	286
Student	41	245	0	286
Health & Environment Indicators				
Pain	175	111	0	286
Chronic disease	32	249	5	286
Respiratory disease	36	244	6	286
Windfarm support	172	114	0	286

Notes: The table above summarises the remaining descriptive statistics of interest.

Calibration Results

Figure 4.2 below shows the frequency of responses to the calibration question by group. There is a large peak around the 100 mark on both graphs. This represents the number of subjects who would allocate the same amount of people to both projects, indicating they have no preference for one project over the other. This would imply that they value both projects equally. The rest of the sample is distributed along the remaining options, with peaks around the 50 and 150 marks, and few individuals choosing the extremes of 1, 199, indicating a strong preference for one of the two projects.

Figure 4.2: FREQUENCY OF NUMBER OF PEOPLE TO ALLOCATE



Notes: The graph displays the results of the calibration exercise. Subjects were ask to allocate a total of 200 people to two different projects, with a minimum of 1 person allocated to each project. The frequency of the number of people allocated to the environment project is displayed on the left while the frequency of the people allocated to the health project is displayed on the right.

This information allows us to divide the sample into 11 groups, one group at the 100 mark, and 10 groups capturing the remaining points on the calibration. The maximum of 199 individuals that can be allocated to one of the two projects implies that dividing this into 10 groups allows each of these groups is set to capture a calibration bracket thickness of 20. Where the first group captures the subjects whose calibration value goes from a calibration of 1/199 (where the first number, 1, is the number of people allocated to the environmental project and the second number, 199, is the number of people allocated to the health project) to a calibration of 20/180. The second group goes from 21/179 to 40/160, etc.

4.4.2 Part 2: Discrete Choice Experiment

The discrete choice experiment (DCE) was carried out in the second week of September 2017, the sample consisted of 250 people recruited through the Prolific Academic research database who had already completed Part 1 of the experiment. The survey remained open for 48 hours to allow a high level of retention of participants.[4] The average completion time for the survey was 10 minutes. With the exception of 8 subjects, all subjects completed the experiment within 40 minutes.

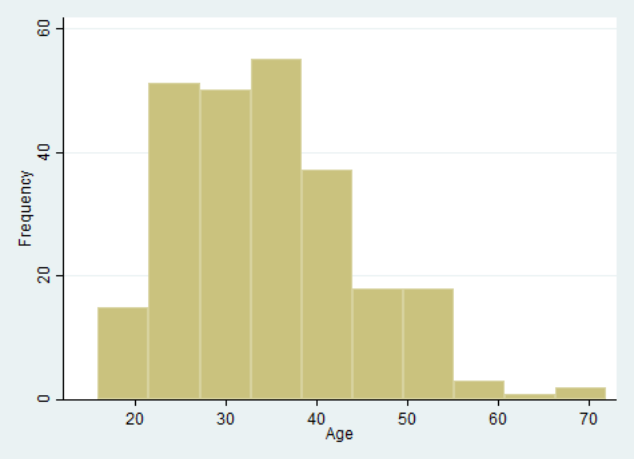
Descriptive Statistics

The mean age was 35 years, 130 subjects (52%) are female, 120 (45%) are male. Once again there is a wide representation of respondents from different age groups as can be seen from Figure 4.3. 89% of respondents are British nationals, 15% are students and

[4]One subgroup (Group 2) is not populated by any subjects. This is the result of a failure of the white list feature on the part of Prolific Academic, who have admitted a fault in their system. Entries were accepted into this group from subjects that were meant to be excluded from it. As a consequence these had to be rejected. Prolific Academic have been contacted about this issue and have yet to provide a full explanation of the technical failure from their end. There were 9 subjects who should have been invited to this group whose data we do not have. As such, albeit a flaw in the study, it is not deemed to have the potential to substantially impact the results of the study.

only one of these is pursuing an economics degree. 74% of respondents are either in full time or part time employment, 26% are either unemployed or inactive. 64% are either married or in a relationship and 56% have children. When it comes to the geographic representation, respondents are spread relatively evenly across the UK. Looking at health indicators we can identify that 9.6% of the sample suffer from chronic diseases such as diabetes, heart disease or stroke. 11% are managing respiratory diseases, and 59% of respondents have had to deal with persistent pain. There is once again a good mix of support for environmental issues such as the use of windfarms which stands at 59%.

Figure 4.3: FREQUENCY OF AGE OF SUBJECTS



Notes: The x-axis displays the age of subjects in years while the y-axis displays the frequency for Part 2 of the experiment, the DCE.

Table 4.4: OTHER DESCRIPTIVE STATISTICS

Variable	Yes	No	Rather not say	Total
Children	139	110	1	250
Student	37	212	1	250
Health & Environment Indicators				
Pain	148	102	0	250
Chronic disease	24	222	4	250
Respiratory disease	28	218	4	250
Windfarm support	148	102	0	250

Notes: The table above summarises the remaining descriptive statistics of interest for the sample of 250 people who went through to the second part of the experiment.

As mentioned in the methodology section above, choice set 7 was presented to subjects twice within the experiment in order to serve as a consistency check. 90% of subjects (199) repeated the same choice in both choice sets while 10% (26) of subjects chose a different alternative in the second choice set when presented with the same exact choice. While the small proportion of inconsistent responses is reassuring, the data analysis was also carried out disregarding the responses of this subset of potentially inconsistent respondents and the results are robust to this check.

Regression Results

The three models outlined in Section 4.3 are analysed using a mixed logit regression, given the possibility that there is heterogeneity in the preferences of subjects. This over-

comes the limitations of the traditional conditional logit estimation. The three models are also estimated using conditional logit and are compared to the mixed logit for goodness of fit using Bayes Information Criteria (BIC). It is clear from these results that the mixed logit estimations provide a better goodness of fit. The regression results for the conditional logit and the goodness of fit comparisons are presented for reference in Appendix A.7.

The tables below display the results of the mixed logit regression on the three different model specifications outline in Section 4.3. The first and second models follow the specifications presented in Viscusi et al. (2008). The mixed logit results assumes the variables have normally distributed coefficients and the number of draws is set at 50.

Table 4.5: MIXED LOGIT REGRESSION RESULTS MODEL 1

VARIABLES	Mean	SD
Constant	0.0323	
	(0.0417)	
Outcome	0.0243***	-0.0189***
	(0.00362)	(0.00322)
Magnitude	0.00757***	0.00512***
	(0.000396)	(0.000405)
Delay	-0.822***	0.457***
	(0.0559)	(0.0383)
Domain	-0.987***	2.795***
	(0.175)	(0.162)
Outcome#Delay	0.00155	-0.00255**
	(0.00119)	(0.00116)
Observations	12,000	
Likelihood-ratio	1755.79	
p-value	0.000	

Notes: The results for the mixed logit regression are displayed. Where Outcome is a continuous variable used to motivate waiting for a delay, Magnitude is a dummy variable that takes on the value of 1 for the larger magnitude, Delay is the waiting period in years, Domain is a dummy variable that takes the value of 1 for the environment domain, The Delay#Outcome is an interacted variable that joins a continuous outcome variable to a categorical delay variable. Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 4.5 presents the results of the partially interacted model, where we estimate the main effects of all the variables and then add an interacted delay and outcome variable. This corresponds to equation 4.3.7 above. The main effects are consistent with

a priori expectations. An increase in magnitude of the alternative increases the utility of that alternative and therefore increases the probability that the alternative is chosen. An increase in the delay with which an alternative occurs decreases the utility of that alternative. In addition we can see that the alternative being an environmental project decreases the utility of that alternative. All three effects are significant at a 95% level of confidence. In addition we observe that the delayed outcome interaction serves to decrease the utility of that alternative, however this effect is not significant.

Table 4.6: MIXED LOGIT REGRESSION RESULTS MODEL 2

VARIABLES	Mean	SD
Constant	0.0237	
	(0.0416)	
Outcome	0.0227***	-0.0178***
	(0.00359)	(0.00304)
Magnitude	0.00768***	0.00446***
	(0.000383)	(0.000372)
Delay	-0.823***	-0.422***
	(0.0590)	(0.0316)
Domain	-1.093***	2.793***
	(0.155)	(0.180)
Outcome#Delay	0.0103***	-0.000661
	(0.00239)	(0.000866)
Outcome#DelaySquared	0.00265***	-0.000225
	(0.000670)	(0.000248)
Observations	12,000	
Likelihood-ratio	1738.47	
p-value	0.000	

Notes: The results for the mixed logit regression are displayed. Where Outcome is a continuous variable used to motivate waiting for a delay, Magnitude is a dummy variable that takes on the value of 1 for the larger magnitude, Delay is the waiting period in years, Domain is a dummy variable that takes the value of 1 for the environment domain, The Delay#Outcome is an interacted variable that joins two continuous variables and the Outcome#DelaySquared is an interacted quadratic variable combining two continuous variables. Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

The second model estimated follows a quadratic model in Viscusi et al. (2008). This corresponds to equation 4.3.8 above. Once again, the main effects for the quadratic model are consistent with *a priori* expectations. Table 4.6 presents the results. An increase in magnitude of the alternative increases the utility of an alternative. An increase in the delay with which an alternative occurs decreases the utility of that alternative and the alternative being an environmental project decreases the utility of that alternative. Interestingly the interacted terms are both positive, albeit small. This suggests that the quadratic specification may not be appropriately capturing the delay outcome trade off that is the base of discounting behaviour. All coefficients are significant at a 95% level of confidence.

The primary purpose of this research is to jointly elicited the coefficients for magnitude, delay and domain and examine their interaction. We specify an interacted model to examine such possible relationships. This corresponds to equation 4.3.9 above. This allows us to test how these *anomalies* relate to each other when jointly influencing utility. In Table A.24 we recalibrate delay to set the longest delay (5 years) as the baseline with the rest of the delays being evaluated as differences from this baseline (-3 years for a 2 year delay and -4 years for a 1 year delay). We also treat delay as continuous and are able to discuss the relationship of this variable and the magnitude and domain variables.

Table 4.7: MIXED LOGIT REGRESSION RESULTS FULLY INTERACTED MODEL

VARIABLES	choice	
VARIABLES	Mean	SD
Constant	0.0639	
	(0.0452)	
Outcome	0.0302***	-0.0213***
	(0.00626)	(0.00249)
Magnitude	0.00825***	0.00445***
	(0.000673)	(0.000311)
Delay	-1.040***	0.455***
	(0.0941)	(0.0307)
Domain	1.685***	-2.957***
	(0.467)	(0.161)
Outcome#Delay	0.00371	0.00229***
	(0.00265)	(0.000815)
Outcome#Magnitude	-0.000767	0.0232***
	(0.00877)	(0.00397)
Outcome#Domain	-0.0323***	-0.00697**
	(0.0115)	(0.00331)
Magnitude#Delay	0.299**	0.0237
	(0.136)	(0.0693)
Magnitude#Domain	-1.519**	-0.172
	(0.751)	(0.140)
Delay#Domain	0.411**	-0.0836***
	(0.181)	(0.0276)
Outcome#Magnitude#Delay	-0.00529	0.00158
	(0.00327)	(0.00122)
Outcome#Magnitude#Domain	0.0369**	0.000911
	(0.0169)	(0.00281)
Outcome#Delay#Domain	-0.00886**	-0.00255***
	(0.00431)	(0.000721)
Magnitude#Delay#Domain	-0.573**	0.0348
	(0.253)	(0.0427)
Outcome#Magnitude#Delay#Domain	0.0116**	-0.00396***
	(0.00578)	(0.00110)
Observations	12,000	
Likelihood-ratio	1813.01	
p-value	0.000	

Notes: The results for the mixed logit regression are displayed. Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

The results in Table A.24 show that most of the interacted variables are statistically significant, suggesting that they are jointly contributing to the evaluation of the utility associated with each defined alternative.

The interpretation of interaction coefficients is not straightforward (Ai and Norton (2003)), the marginal effect cannot be interpreted as we would a main effect. This is due to the very nature of interaction terms. When we interact two (or more) variables, we essential imply that the way one explanatory variable impacts our dependent variable changes as the values of a second explanatory variable changes. This means the marginal effect of this interaction will depend on the individual levels of the two (or more) variables that are being interacted. It is therefore not meaningful to directly interpret interaction terms in the way we do for main effects. We therefore apply a high level of caution to interpreting the coefficients of the fully interacted model and do not make attempts to make conclusions about the size of these effects.

The results of the likelihood ratio tests produced from the mixed logit regression that test the joint significance of the standard deviation coefficients and the results of the individual p-values of these variables indicate that there is significant preference heterogeneity for the attributes. It is interesting to note that for the Domain attribute, the standard deviation in the results is larger than the mean. The larger spread of the data for this attribute indicates that the impact of Domain on utility is substantially different for different subjects, ranging from positive to negative. This could be indicative of why research into the impact of domain differences in discounting has struggled to find a clear and consistent effect, especially in the environmental domain.

We use the parameter estimates from the mixed logit regression in Table A.24 to work out the average utility associated with each possible combination of attributes. This gives us a total of 24 levels of utility which as displayed in Tables 4.8 below.

Table 4.8: UTILITY LEVELS USING REGRESSION COEFFICIENTS FROM FULLY INTERACTED REGRESSION

Small Magnitude - Health						Small Magnitude - Environment					
Outcome 10			Outcome 50			Outcome 10			Outcome 50		
Delay=1						Delay=1					
Levels		Utility	Levels		Utility	Levels		Utility	Levels		Utility
M	0	4.450	M	0	5.186	M	0	4.376	M	0	4.988
N	1		N	1		N	0		N	0	
D	-4		D	-4		D	-4		D	-4	
O	10		O	50		O	10		O	50	
Delay=2						Delay=2					
Levels		Utility	Levels		Utility	Levels		Utility	Levels		Utility
M	0	3.769	M	0	4.299	M	0	3.373	M	0	4.134
N	1		N	1		N	0		N	0	
D	-3		D	-3		D	-3		D	-3	
O	10		O	50		O	10		O	50	
Delay=5						Delay=5					
Levels		Utility	Levels		Utility	Levels		Utility	Levels		Utility
M	0	1.727	M	0	1.640	M	0	0.366	M	0	1.572
N	1		N	1		N	0		N	0	
D	0		D	0		D	0		D	0	
O	10		O	50		O	10		O	50	
Large Magnitude - Health						Large Magnitude - Environment					
Outcome 10			Outcome 50			Outcome 10			Outcome 50		
Delay=1						Delay=1					
Levels		Utility	Levels		Utility	Levels		Utility	Levels		Utility
M	1	4.144	M	1	5.317	M	1	3.390	M	1	4.818
N	1		N	1		N	0		N	0	
D	-4		D	-4		D	-4		D	-4	
O	10		O	50		O	10		O	50	
Delay=2						Delay=2					
Levels		Utility	Levels		Utility	Levels		Utility	Levels		Utility
M	1	3.252	M	1	4.471	M	1	2.634	M	1	3.999
N	1		N	1		N	0		N	0	
D	-3		D	-3		D	-3		D	-3	
O	10		O	50		O	10		O	50	
Delay=5						Delay=5					
Levels		Utility	Levels		Utility	Levels		Utility	Levels		Utility
M	1	0.577	M	1	1.935	M	1	0.366	M	1	1.542
N	1		N	1		N	0		N	0	
D	0		D	0		D	0		D	0	
O	10		O	50		O	10		O	50	

Notes: The parameter estimates obtained from the mixed logit regression allow us to work out the total utility allocated to each combination of attributes, or scenario. The table displays the level of average

Using the changes in total utility in the table above the effect of delay can be isolated by comparing two scenarios where all the remaining attributes, except delay, remain constant. This can, for example, be calculated by looking at the total utility for the scenario in the second row of Table 4.8 where M=0, N=0, D=-3 and O=10 and compared to the one above it where M=0, N=0m D=-4 and O=10. The only thing that distinguishes these two scenarios is the delay, and therefore the change in utility can only be attributed to the effect of the delay. Using this ability of the random utility model to isolate the impact of delay and the changes in utility the associated discount factors and discount rates are calculated and presented in Table 4.9 below.[5]

[5]By comparing pairs of scenarios where the only attribute that changes is delay we can extract the change in utility attributable to the change in delay (as everything else in that scenario pair remains constant). The utility that we calculate is the already discounted utility rather than instantaneous utility and the change in this discounted utility is directly linked to the change in the value of the discount factor itself as the instantaneous utility of two scenarios that are identical is itself identical. The discount factor is found by solving the following equation for δ; $V_a\delta^t = V_b$ where V_a is the utility from the closer delay, V_b is the utility from the longer delay, t is the time lag between the two delays and δ is the discount factor. The discount rate is calculated using $DR = \frac{1}{DF} - 1$.

Table 4.9: DISCOUNT FACTORS AND DISCOUNT RATES

Health / Small Magnitude					Environment / Small Magnitude				
Outcome 10					Outcome 10				
Del	V_a	V_b	DF	DR	Del	V_a	V_b	DF	DR
1	4.450	3.769	0.847	18%	1	4.376	3.373	0.771	30%
3	3.769	1.727	0.771	30%	3	3.373	0.366	0.477	110%
Outcome 50					Outcome 50				
1	5.186	4.299	0.829	21%	1	4.988	4.134	0.829	21%
3	4.299	1.640	0.725	38%	3	4.134	1.572	0.724	38%
Health / Large Magnitude					Environment/ Large Magnitude				
Outcome 10					Outcome 10				
Del	V_a	V_b	DF	DR	Del	V_a	V_b	DF	DR
1	4.144	3.252	0.785	27%	1	3.390	2.634	0.777	29%
3	3.252	0.578	0.562	78%	3	2.634	0.366	0.518	93%
Outcome 50					Outcome 50				
1	5.317	4.471	0.841	19%	1	4.818	3.999	0.830	20%
3	4.471	1.935	0.756	32%	3	3.999	1.542	0.728	37%

Notes: By taking the utility works from 4.8 we can conduct pairwise comparisons between two utilities whose only difference is the delay period. This comparison yields a discount factor and consequently a discount rate. The results for the discount factor (DF) and discount rate (DR) workings for these pairwise comparisons are displayed above, where V_a represents the utility from the closer delay, V_b represents the utility from the longer delay and Diff refers to the difference between the two utilities.

The discount rates elicited for each of the 8 scenarios generally support the findings in literature that annual discount rates for larger magnitudes are smaller than those for smaller magnitudes. We are, however, unable to confirm the delay effect in our data as the implied annual discount rate for a 3 year delay is larger than that for a one year delay.

In order to compare the differences between these discount rates that have been computed and test whether these differences are statistically different from zero we carry out t-tests on the difference between pairs of discount rates. We use the parameter estimates obtained from the fully interacted regression, presented in Table A.24 to compute the discount rates used for the comparison, in the same way they are computed in Table 4.9. The null hypothesis is that there is no statistical difference between each pair of discount rates that is compared. A low p-value indicates we can reject this null of no difference. The results are presented in Table 4.10.

Table 4.10: DISCOUNT RATE COMPARISONS

Magnitude	Small Mag	Large Mag	Diff in DR	p-value
N=0,O=10, D=1	29.7%	28.7%	0.0102	0.089
N=0,O=10, D=3	109.7%	93.0%	0.1670	0.079
N=0,O=50, D=1	20.7%	20.5%	0.0018	0.945
N=0,O=50, D=3	38.0%	37.4%	0.0064	0.945
N=1,O=10, D=1	18.1%	27.4%	-0.0935	0.091
N=1,O=10, D=3	29.7%	77.9%	-0.4819	0.231
N=1,O=50, D=1	20.6%	18.9%	0.0171	0.500
N=1,O=50, D=3	37.9%	32.2%	0.0568	0.511

Domain	Health	Environment	Diff in DR	p-value
M=0, O=10, D=1	18.1%	29.7%	-0.1166	0.000
M=0, O=10, D=3	29.7%	109.7%	-0.8003	0.000
M=0, O=50, D=1	20.6%	20.7%	-0.0004	0.984
M=0, O=50, D=3	37.9%	38.0%	-0.0014	0.984
M=1, O=10, D=1	27.4%	28.7%	-0.0129	0.712
M=1, O=10, D=3	77.9%	93.0%	-0.1631	0.635
M=1, O=50, D=1	18.9%	20.5%	-0.0157	0.351
M=1, O=50, D=3	32.2%	37.4%	-0.0517	0.366

Delay	1 Year Del	3 Year Del	Diff in DR	p-value
N=0, M=0, O=10	29.7%	109.7%	-0.8002	0.000
N=0, M=0, O=50	20.7%	38.0%	-0.1737	0.001
N=0, M=1, O=10	28.7%	93.0%	-0.6434	0.000
N=0, M=1, O=50	20.5%	37.4%	-0.1691	0.001
N=1, M=0, O=10	18.1%	29.6%	-0.1165	0.036
N=1, M=0, O=50	20.6%	37.9%	-0.1727	0.003
N=1, M=1, O=10	27.4%	77.9%	-0.5049	0.121
N=1, M=1, O=50	18.9%	32.2%	-0.1330	0.000

Notes: The results for the discount rate comparisons are displayed above. The discount rates presented in the second and third columns correspond to those presented in Table 4.9. The 1 year delay refers to the comparison between the utility generated for a 1 year and a 2 year delay, while the 3 year delay refers to the comparison between the utility generated for a 2 year and a 5 year delay.

From the table above it is clear that, even though not all the differences are significant, some apparently small differences in discount rates are in fact statistically significant, especially for the larger magnitudes and levels of outcome. The economic significance of a small difference in discount rates is of course dependent on the context. In policy evaluation even a 1% difference in the policy discount rate used will have substantial implications of the net present value of an investment or policy.

4.5 Conclusion and Discussion

This paper elicits, for the first time, the preferences of individuals for delayed outcomes while simultaneously varying a number of discounting dimensions, or *anomalies*. This is done by adapting the discrete choice experiment set up to incorporate discounting dimensions as attributes.

We confirm that the three dimensions included, delay, domain and magnitude, are significant in influencing the utility associated with the outcome. In addition, from the results in Table A.23 it is clear that all interacted variables are statistically significant, suggesting that they are jointly contributing to the evaluation of the utility associated with each defined alternative. This implies that they are influencing utility jointly and that the impact each dimension has on the discounting choices of subjects is dependent on the implicit level of the remaining dimensions. The significance of *anomalies* is not a novel finding, however the strong interactions between *anomalies* has not been tested and raises several interesting questions about the way we elicit discount rates.

Traditionally research into discounting has looked into deviations from the Discounted Utility Model by focusing on one or two anomalies at a time and elicited them in a between-subject design. While this has greatly expanded our understanding of the discounting processes and served to highlight the limitations of the Model, we are yet to reach a consensus as to what to replace this model with. Focusing on individual deviations means we treat these *anomalies* as independent curiosities. They are actually integral parts of the discounting landscape and models need to integrate all aspects of

the decision environment in order to truly replicate the intertemporal decision process.

The workhorse model of discrete choice experiments has been shown to be truly adaptable to applications in discounting experiments. It has proved to be capable of handling the complex intricacies of multi-attribute elicitation and allows for the estimation of both main and interacted effects to allow for discount rate elicitation. In addition it is also to handle a fully interacted model that allowed us to capture the full effect of all the dimensions presented to subjects. The number of choice sets are not substantially different from the typical number of repeated binary questions presented to subjects in a traditional payment ladder format used in time preference elicitation experiments.

The study, however, is not without limitations. We have only incorporated three dimensions of discounting. Incorporating an increased number of dimensions would shed greater light on the complexities of discounting. It is important to highlight that the inclusion of more *anomalies* would grow this design in an exponential manner. Some dimensions, such as gains vs. losses, might require an additional layer of creativity to incorporate outcomes into one coherent hypothetical scenario. This would be a challenge for future research to undertake. Using DCEs and online experimental methodology this is, however, an achievable objective.

The relevance of this work for policy makers lies in the new awareness of how deep the complexity of discounting calculations goes in the decision making process of agents. Policy makers need to recognise that the evaluation of issues, such as climate change, that span over multiple decades and centuries are intensely complex and we cannot reasonably expect individuals with only general knowledge of outcomes and consequences to appropriately process the present day implications of these distant outcomes. As such, environmental policy needs to operate under the assumption that agents will not be acting in their best interest when making daily intertemporal environmental decisions and may require guidance to fully internalise the future implications of their decisions.

It is clear from the research that making intertemporal choices is a highly complex operation. Yet people make these decisions on a daily basis. Being able to understand

what influences these choices and how these influences come together is key to understanding intertemporal choice. The future for research lies with taking a more comprehensive approach to incorporating discounting dimensions into standard elicitation techniques. In addition, a concerted effort to harmonise these many dimensions would lay the ground work for an overarching discounting model.

5

Conclusion

Time and risk preferences are key drivers of many of the choices we make on a daily basis. We are continuously drawing on them to make some of the most important decisions in our day-to-day lives. Whether we save enough for our retirement, whether we engage in a healthy lifestyle, and whether we invest sufficiently in reducing the impact of humans on our planet all depend on the collection of individual preferences of people, companies and governments that are based on their ability to internalise future time periods and on their tolerance of risk. Our knowledge about the true nature of these preferences is, however, still in a state of development.

This thesis sought to contribute to the body of knowledge on time and risk preferences by investigating a number of nuances of discounting and risk preferences. The principal contribution of this thesis is to highlight the interactions of the many dimensions of discounting in the process of individuals evaluating intertemporal outcomes. It has, for the first time, jointly elicited multiple *anomalies* simultaneously and shown

that the impact of these well-documented *anomalies* is itself dependent on the level of other *anomalies*. The practice of isolating *anomalies* for investigation, while sufficient to serve as proof of the existence of each *anomalies* does little to progress our understanding about how the overall intertemporal decision is made. This thesis suggests that the path towards improving this understanding lies in improving these simultaneous elicitation techniques. Due to this interdependence of *anomalies* the findings of the experiments carried out in this thesis cannot be generalised into larger goods, goods of different nature or to time delays that span longer time frames. They can however give an indication of what aspects of decision making matter in these cases. In addition the complexity involved in making intertemporal health and environment decisions deserves increased attention. We show that these decisions suffer from hypothetical bias due to the additional cognitive burden they impose. It is important for experimenters to ensure that they consider this dimension in their experimental design and attempt to mitigate for it.

The thesis has looked at the impact of risk and discounting *anomalies* on these preferences and has investigated the elicitation of these preferences in hypothetical and in multi-attribute scenarios. One of the *anomalies* investigated initially was **domain**. The first experiment investigated whether time and risk preferences were consistent regardless of the domain of the decision as is prescribed in the discounted utility and expected utility models. The second experiment looked at the elicitation environment and focused on whether incentives were needed in order to elicit true preferences of these parameters. The third experiment looked at eliciting time preference in a multi-attribute environment, by varying a number of things simultaneously and not isolating, and therefore magnifying, time preference.

The results of the first experiment, which found that individuals are more risk averse when playing with environmental goods, raises interesting questions about the underlying motives for this difference. The experiment was not designed to investigate the reasons for such differences and therefore it opens up a set of new research questions in this area about the driving motivations for the impact of domain. Is it merely unfamiliarity in environmental decision making or is it rather that people are in fact feeling

a greater impact of expected environmental losses and therefore less willing to gamble with environmental goods?

The results from the second experiment, comparing incentivised and hypothetical settings, where it was found that incentives mostly impact the variance of responses given especially for tasks that require higher cognitive effort, indicates that we must do our best to simplify the way we elicit time preferences. The elicitation of risk preferences have developed into neat tradeoffs that allow for identification of risk parameters. The elicitation of discount rates appears clumsy by comparison and requires further development. There is a clear gap in the literature that calls for an improved methodology for such elicitation that simplifies and harmonises the discounting task.

The third experiment contributed to showing that ignoring the various *anomalies* renders any investigation into time and risk is severely limiting. The impact of magnitude, domain, and the numerous other *anomalies* needs to be integrated into each investigation of time and risk in order to extract results that are meaningful. In addition, isolating these preferences one by one does little to address the fact that they impact choice in an interacted manner. They do not have the same impact consistently. Rather, this varies according to their respective states. This may be disconcerting for researchers due to the implied complications that arise from attempting to vary multiple anomalies simultaneously. The final paper, however, shows that the methodological and econometric techniques to do so exist. If such interactions are unable to be added to the elicitation of these preferences then it follows that the conclusions of such studies are limited in external validity to situations that are similar to those being studied. Attempts to make wider conclusions based upon limited experiments should be treated with great caution.

The three papers add substantial information about how individuals process intertemporal decisions. Apart from their individual contributions, their combined contribution sheds light on our understanding of the complexities involved in eliciting discount rates and in the very process of evaluating intertemporal outcomes. It is interesting that domain differences in discounting could not be verified in the second chapter, however emerge in how subjects evaluate real and hypothetical outcomes and emerge very

strongly when examined under the DCE methodology.

While it has been known for years that the standard discounted utility and expected utility models were merely benchmark models and not true reflections of the dynamics of time and risk preferences, the intertemporal decision process seems to be even more nuanced than might have been thought. Discounting *anomalies* have a substantial impact on the preferences we elicit.

The main contribution of this thesis with respect to environmental policy lies in the exposition of the nuances that have been uncovered in how individuals evaluate outcomes that span multiple time periods. It serves to shed light on the fundamental reason we even consider discounting in the first place, it is because of the nature of human beings, and their preferences. The relevance to policy lies in improving our understanding in how people actually evaluate these complex decisions. It is not always the case that policy decisions should mirror private decisions. In fact, in cases such as pension saving, policy makers have used the inability of individuals to properly internalise their future needs and appropriately save for their retirement as justification for government intervention in this area to encourage improved saving behaviour. I would argue that research into individual discounting behaviour, and the clear message about how complex these decisions are and how many dimensions impact the value of discount rates elicited, would suggest that policy rates should not rely on observed behaviour. It is indeed my opinion that policy discount rates should be the result of ethical and political evaluation of the future that a country would like to leave for the next generation rather than the current behaviour of its individual inhabitants. The findings in this thesis can support policy in designing softer approaches to encourage greater forward thinking behaviour in spite of individual myopia, considering what dimensions of discounting encourage lower temporal weightings.

The findings in this thesis are based on the foundations of experimental economics, and rise and fall with the strengths and weaknesses of that methodology. The first two papers were limited by a sample made up of university students who are unlikely to be representative of the general population. This was a limitation overcome in the

third paper thanks to the use of online experiments to recruit from a wider, and more representative, sample pool. Experiments are simplifications of complex problems faced by decision makers, and thus suffer from an element of external validity when applied to a wider decision making context. Once again the third paper attempted to bring an extra element of complexity by using the DCE methodology to replicate multiple simultaneous changes. Other limitations include the goods used in the experiments, which were public goods (in the case of the environmental instrument) that elicited a small value and was only delayed in the short-term. Since it is clear that all these dimensions matter when it comes to discounting it is not clear that the findings of this thesis will extend to larger goods with longer delays.

These limitations stem from the challenges involved in eliciting discount rates in an incentivised manner for larger environmental outcomes with long delays. These would be better suited to hypothetical elicitation. From the findings in Chapter 3 we can support hypothetical elicitation under conditions where the cognitive effort is reduced. This would imply that subjects are made familiar with the good being discounted and the experiment is presented in a way to minimise cognitive strain. It may also be possible to carry out a calibration exercise to estimate the extent of hypothetical bias in discount rate elicitation, in a similar way as was done for willingness to pay estimation (Blackburn et al. (1994)). This is, however, made more challenging by the interrelated nature of the relationship between discounting *anomalies*. Again the findings for one magnitude, or one domain, will be hard to extend to others.

As with many research projects, the process of designing and undertaking research focuses attention to narrow questions that we have the resources and ability to answer. The original instigation of this PhD was to look at why individuals displayed myopia when it came to environmental outcome evaluation. This wide question is far from being answered. However this thesis has shed substantial insight into various intricacies surrounding this complex decision parameter. The more complex practical issues faced in this thesis were the transformation of large complex environmental issues into simpler outcomes that could be explained and replicated in a lab / DCE setting. This is a challenge shared by researchers working on environmental economics. In addition,

adapting the standard DCE methodology to incorporate discounting *anomalies* as dimensions presented a tough conceptual challenge. Future research would benefit from further reflection on the suitability of this methodology in supporting the development of a discounting model with improved explanatory power.

Operating without funding or time constraints would have allowed for the extension of this research to incorporate goods of a different nature, longer term environmental outcomes that are of larger magnitudes. In addition it would have allowed for research to incorporate increased *anomalies* in the DCE, specifically the gains vs. losses, and the speed-up/slow-down dimensions.

The future for research on risk and discounting is challenging and the investigation into *special cases* can enrich our understanding by providing the foundation for more big-picture research. However, what is strongly needed is unifying work that can bring these various strands together into a more concrete understanding of how individuals process these abstract concepts of time and risk. Without this unification the discipline will not be able to contribute to the development of policy interventions that can bring about change in important policy areas such as pension saving and climate change and, rather, ensures that time and risk preferences remain the subject of curiosity for academics.

APPENDIX A

Appendices

A.1 Experimental Instructions for Chapter 2

A.1.1 Set A1

The specific set of experimental instructions (referred to as A1 in the manuscript) consists of the instructions given to subsample A1. Subsample A1 was presented with the following tasks in this order: Monetary Discounting, Monetary Risk Aversion Test, Environmental Discounting, Environmental Risk Aversion Test, Cognitive Reflection Test, Environmental Questionnaire and the Questionnaire. The Experimental Instructions for subsamples A2, B1 and B2 are analogous to those for subsample A1. The only difference is the order in which the first four tasks were presented. The titles of the stages were omitted from the experimental instructions given to subjects.

Instructions

The purpose of this experimental session is to study how people make decisions in a particular situation.

The experimental session consists of **seven** stages to be described at the appropriate time.

The instructions are the same for all participants.

For your participation in the experimental session, you will receive a £5 as a participation fee. In addition, you will have the opportunity to increase your earnings.

At the end of the session, when all the participants have completed all seven stages, you will be paid your total earnings. Your total earnings will be placed in a payment envelope. The instructions are simple, yet if you have a question please raise your hand. Aside from these questions, any communication with other participants or looking at other participants' screens is not permitted and will lead to your immediate exclusion from the experiment.

All information collected during the experiment will be kept **strictly confidential** and data will be handled in line with the Data Protection Act 1998.

If you would like further clarification, please raise your hand and the experimenter will come by shortly to answer your questions, otherwise please click the Next button.

Monetary Discounting (MD)

Stage 1

Your responses in this Stage might be selected for payment.

This Stage consists of three blocks of 6 questions in each block for a total of 18 questions. The questions will require you to make a choice between a smaller monetary outcome occurring at one point in time and another larger monetary outcome occurring at a later point in time. The time delay is identical **within** each block but will change **between** blocks.

Example

Please select which of the following you prefer:

£50 payable in 1 month from today.

£55 payable in 7 months from today.

If you would like further clarification, please raise your hand and the experimenter will come by shortly to answer your questions, otherwise please click the Next button.

[The following choices were displayed one by one on the subjects' screens.]

Table A.1: BINARY CHOICES PRESENTED IN MD

Binary Choice	
Smaller Sooner	Larger Later
£50	£55
£50	£60
£50	£65
£50	£70
£50	£75
£50	£100

Notes: In the first column, we present the smaller sooner amount, which is the amount that would be available to subjects after the one month front-end delay, while in the second column, we present the larger later amount, which is the amount that would be available to subjects after the specified delay period. Subjects answered three sets of these six questions, one for each of the time-delay periods: (i) the 3-month delay period, (ii) the 6-month delay period, and (iii) the 12-month delay period.

As indicated earlier, your responses in this Stage might be selected for payment at the end of the experimental session. Here is how.

A participant in the lab today will be selected at the end of the experimental session using the bingo machine on the side. Each participant has an equal chance of being selected.

The selected participant will face another two draws. The first draw will determine the Stage (either Stage 1 or Stage 3), and the second will identify one specific question from the selected Stage. All the draws will be carried out using the bingo machine.

Recall that you will respond to a total of 18 questions in this Stage (3 blocks of six questions in each block), and will answer another 18 questions in Stage 3. Based on the selected participant's response in the specific question drawn, the selected participant will get paid.

For example, assume you are the selected participant, this Stage was drawn, and in the specific question drawn you had responded that you would rather have £X in Y months. Then, the experimenter will put a completed **Requisition Form** for £X with the payment date in Y months' time in your payment envelope.

Note: A **Requisition Form** is an official request for payment that can be submitted to the University of Southampton. Requisition Forms will be paid on the date specified in the question (in this example in Y months' time) provided you fill in the necessary details on the form.

If you would like further clarification, please raise your hand and the experimenter will come by shortly to answer your questions, otherwise please click the Next button.

Monetary Risk Aversion Test (MRAT)

Stage 2

Your response in this Stage might be selected for payment.

In this part of the study, you are asked to choose one of the five options shown below. Regardless of which option you choose, there are two possible outcomes (Outcome X and Outcome Y). These outcomes are equally likely in all five options - there is a 50% chance of Outcome X and a 50% chance of Outcome Y, just like the flip of a coin. The options differ only in how much each outcome pays.

If you would like further clarification, please raise your hand and the experimenter will come by shortly to answer your questions, otherwise please click the Next button.

[The following options were displayed to subjects in the same format as shown below.]

Table A.2: OPTIONS PRESENTED IN MRAT

Option	Outcome	Payoffs (£)	Probability
1	X	50.00	50%
	Y	50.00	50%
2	X	35.00	50%
	Y	87.50	50%
3	X	25.00	50%
	Y	112.50	50%
4	X	15.00	50%
	Y	137.50	50%
5	X	5.00	50%
	Y	162.50	50%

Notes: In the first column, we list the 5 options available to subjects. In the second column, we list the possible outcomes of each option: Outcome X or Outcome Y. In the third column, we list the payoffs associated with each outcome in each option, and in column four, we list the probability of that specific outcome occurring given the subject picked that option.

As indicated earlier, your response in this Stage might be selected for payment at the end of the experimental session. Here is how.

A participant in the lab today will be selected at the end of the experimental session using the bingo machine on the side. Each participant has an equal chance of being selected.

The selected participant will face another two draws. The first draw will determine the Stage (either Stage 2 or Stage 4), and the second will identify the outcome (either Outcome X or Outcome Y). All the draws will be carried out using the bingo machine.

You will choose one option in this Stage and one option in Stage 4. The selected participant will be paid based on the stage drawn, the outcome drawn, and the selected participant's option choice.

For example, assume you are the selected participant, this stage is drawn, and you chose Option 2; then, you will either earn £35 if Outcome X occurs or £87.50 if Outcome Y occurs. If you chose Option 4, then, you will either earn £15 if Outcome X occurs or £137.50 if Outcome Y occurs. The experimenter will put a completed Requisition Form for your earnings with today's date as the payment date in your payment envelope.

You will only find out the outcome at the end of the experimental session. The options will be displayed again when you begin the Stage.

If you would like further clarification, please raise your hand and the experimenter will come by shortly to answer your questions, otherwise please click the Next button.

Environmental Discounting (ED)

Stage 3

Your responses in this Stage might be selected for payment.

An Environmental Project is going to be carried out at the University of Southampton between April 2014 and April 2015. The project has been sponsored by various grants.

On four separate occasions, volunteers will be distributing free, bee-friendly plants to staff and students at the University's Highfield campus.

The plants will be chosen depending on the time of year they are to be planted, in order to ensure that they are immediately beneficial to bees, and to require little care outside of the original planting.

Bees are behind much of the food we eat as they pollinate the plants that produce most of our fruit and vegetables. Bees, however, face numerous threats and their numbers are declining due to changes in land use, building projects, pesticides, pollution and climate change.

Small changes, such as planting nectar-rich flowers, can help restore bee populations. Bee-friendly plants can attract up to 100 times as many bees. Feeding havens in the middle of an urban jungle have great value. The project will help create bee-friendly communities.

In this stage, the choices you make will increase the number of plants distributed in this project.

If you would like further clarification, please raise your hand and the experimenter will come by shortly to answer your questions, otherwise please click the Next button.

This Stage also consists of three blocks of 6 questions in each block for a total of 18 questions. The questions will require you to make a choice between a smaller environmental outcome occurring at one point in time and another larger environmental outcome occurring at a later point in time. The time delay is identical **within** each block but will change **between** blocks.

Example
Please select which of the following you prefer:

10 plants that will be distributed in 1 month from today.

11 plants that will be distributed in 7 months from today.

If you would like further clarification, please raise your hand and the experimenter will come by shortly to answer your questions, otherwise please click the Next button.

[The following choices were displayed one by one on the subjects' screens.]

Table A.3: BINARY CHOICES PRESENTED IN ED

Binary Choice	
Smaller Sooner	Larger Later
10 plants	11 plants
10 plants	12 plants
10 plants	13 plants
10 plants	14 plants
10 plants	15 plants
10 plants	20 plants

Notes: In the first column, we present the smaller sooner amount, which is the amount that would be available to subjects after the one month front-end delay, while in the second column, we present the larger later amount, which is the amount that would be available to subjects after the specified delay period. Subjects answered three sets of these six questions, one for each of the time-delay periods: (i) the 3-month delay period, (ii) the 6-month delay period, and (iii) the 12-month delay period.

As indicated earlier, your responses in this Stage might be selected for payment at the end of the experimental session. Here is how.

As was explained in Stage 1, a participant in the lab today will be selected at the end of the experimental session using the bingo machine on the side. Each participant has an equal chance of being selected.

The selected participant will face another two draws. The first draw will determine the Stage (either Stage 1 or Stage 3), and the second will identify one specific question from the selected Stage. All the draws will be carried out using the bingo machine.

Recall that you will respond to a total of 18 questions in this Stage (3 blocks of six questions in each block), and have already answered another 18 questions in Stage 1. Based on the selected participant's response in the specific question drawn, the selected participant will get paid.

For example, assume you are the selected participant, this Stage was drawn, and in the specific question drawn you had responded that you would rather have X plants in Y months. Then, the experimenter will add X plants to the environmental project and they will be distributed on campus in Y months' time. You will be informed in advance about the exact project date and you may choose to receive an email update about the event.

If you would like further clarification, please raise your hand and the experimenter will come by shortly to answer your questions, otherwise please click the Next button.

Environmental Risk Aversion Test (ERAT)

Stage 4

Your response in this Stage might be selected for payment.

In this part of the study, you are asked to choose one of the five options shown below. Regardless of which option you choose, there are two possible outcomes (Outcome X and Outcome Y). These outcomes are equally likely in all five options - there is a 50% chance of Outcome X and a 50% chance of Outcome Y, just like the flip of a coin. The options differ only in how much each outcome pays.

If you would like further clarification, please raise your hand and the experimenter will come by shortly to answer your questions, otherwise please click the Next button.

[The following options were displayed to subjects in the same format as shown below.]

Table A.4: OPTIONS PRESENTED IN ERAT

Option	Outcome	Payoffs (plants)	Probability
1	X	10 plants	50%
	Y	10 plants	50%
2	X	7 plants	50%
	Y	18 plants	50%
3	X	5 plants	50%
	Y	23 plants	50%
4	X	3 plants	50%
	Y	28 plants	50%
5	X	1 plant	50%
	Y	33 plants	50%

Notes: In the first column, we list the 5 options available to subjects. In the second column, we list the possible outcomes of each option: Outcome X or Outcome Y. In the third column, we list the payoffs (in plants) associated with each outcome in each option, and in column four, we list the probability of that specific outcome occurring given the subject picked that option.

As indicated earlier, your response in this Stage might be selected for payment at the end of the experimental session. Here is how.

As was explained in Stage 2, a participant in the session today will be selected at the end of the experimental session using the bingo machine on the side. Each participant has an equal chance of being selected.

The selected participant will face another two draws. The first draw will determine the Stage (either Stage 2 or Stage 4), and the second will identify the outcome (either Outcome X or Outcome Y). All the draws will be carried out using the bingo machine.

You will choose one option in this Stage, and have already chosen one option in Stage 2. The selected participant will be paid based on the stage drawn, the outcome drawn, and the selected participant's option choice.

For example, assume you are the selected participant, this Stage is drawn, and you choose Option 2; then, you will either get 7 plants if Outcome X occurs or 18 plants if Outcome Y occurs. If you choose Option 4, then, you will either get 3 plants if Outcome X occurs or 28 plants if Outcome Y occurs. These plants will be added to the environmental project.

You will only find out the outcome at the end of the experimental session. The options will be displayed again when you begin the Stage.

If you would like further clarification, please raise your hand and the experimenter will come by shortly to answer your questions, otherwise please click the Next button.

Cognitive Reflection Test (CRT)

Stage 5

Your responses in this Stage will not be paid.

In this part of the study you are asked to respond to three questions. Please choose your option by clicking on a radio button. You will be asked to confirm your choice before you move to the next screen.

If you would like further clarification, please raise your hand and the experimenter will come by shortly to answer your questions, otherwise please click the Next button.

- A bat and a ball cost $\pounds 1.10$ in total. The bat costs $\pounds 1.00$ more than the ball. How much does the ball cost?

  A. $\pounds 0.10$
  B. $\pounds 0.05$
  C. $\pounds 0.02$
  D. $\pounds 0.08$

- If it takes 5 machines, 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?

  A. 5 minutes
  B. 6 minutes
  C. 100 minutes
  D. 10 minutes

- In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the

patch to cover half of the lake?

A. 37 days

B. 24 days

C. 42 days

D. 47 days

Environmental Questionnaire (EQ)

Stage 6

Your responses in this Stage will not be paid.

In this part of the study, you are asked to respond to questions of an environmental nature.

Please choose your option by clicking on a radio button.

If you would like further clarification, please raise your hand and an experimental assistant will come by shortly to answer your questions, otherwise please click the Next button.

Valuation Question

Imagine you are given a one-off opportunity to sponsor a plant to be added to this project. How much would you be willing to pay for one bee-friendly plant?

- £0.00
- £0.50 - £2.50
- £2.50 - £5.00
- £5.50 - £10.00
- £10.50 - £15.00
- £15.50 and above

Environmental Statements

I would only travel by bus if I had no other choice.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

For the sake of the environment, car users should pay higher taxes.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

People who fly should bear the cost of the environmental damage that air travel causes.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree

- Strongly disagree
- Don't know

I don't pay much attention to the amount of water I use at home.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

People have a duty to recycle.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

We are close to the limit of the number of people the earth can support.

- Strongly agree
- Tend to agree
- Neither agree nor disagree

- Tend to disagree
- Strongly disagree
- Don't know

The Earth has very limited room and resources.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

If things continue on their current course, we will soon experience a major environmental disaster.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

The so-called 'environmental crisis' facing humanity has been greatly exaggerated.

- Strongly agree

- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

It would embarrass me if my friends thought my lifestyle was purposefully environmentally friendly.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

Being green is an alternative lifestyle, it's not for the majority.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

I find it hard to change my habits to be more environmentally friendly.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

It's only worth doing environmentally-friendly things if they save you money.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

The effects of climate change are too far in the future to really worry me.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

It's not worth me doing things to help the environment if others don't do the same.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

It's not worth Britain trying to combat climate change, because other countries will just cancel what we do.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

Which of these best describes how you feel about your current lifestyle and the environment?

- I'd like to do a lot more to help the environment
- I'd like to do a bit more to help the environment
- I'm happy with what I do at the moment

- Don't Know

Questionnaire (Q)

Stage 7

Your responses in this Stage will not be paid.

In this part of the study you will complete a questionnaire. The questionnaire asks you to answer some questions about yourself. You will always have the option to not answer a question if you don't wish to provide some information. Failure to provide information will NOT affect your ability to participate in the remainder of the experiment.

1. What is your age?

2. What is your gender?

Male

Female

Prefer not to answer

3. On average, in a typical month, how much do you spend on non-accommodation expenses? (Please count the total expenditure on food, entertainment, clothes, mobile phone bills, and transport, but exclude rent/mortgage repayment)

4. Do your parents own or rent the house in which they now live?

Own

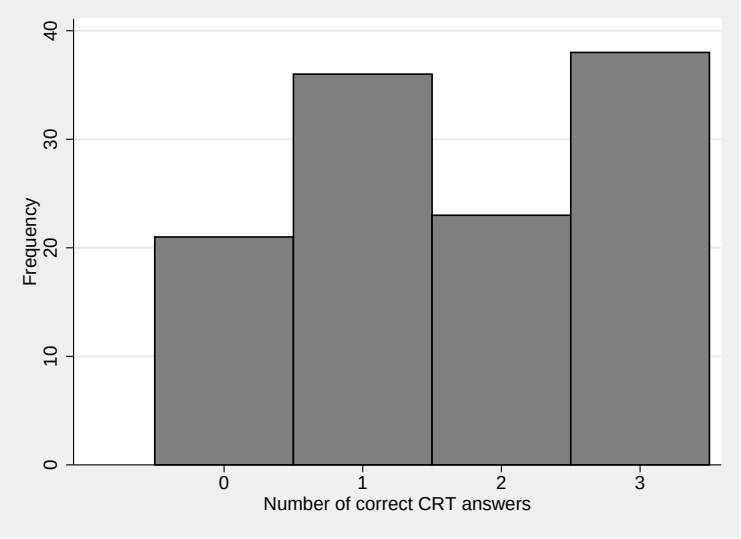
Rent

Prefer not to answer

A.2 Supplementary Tables and Charts to Chapter 2

A.2.1 Cognitive Reflection Test

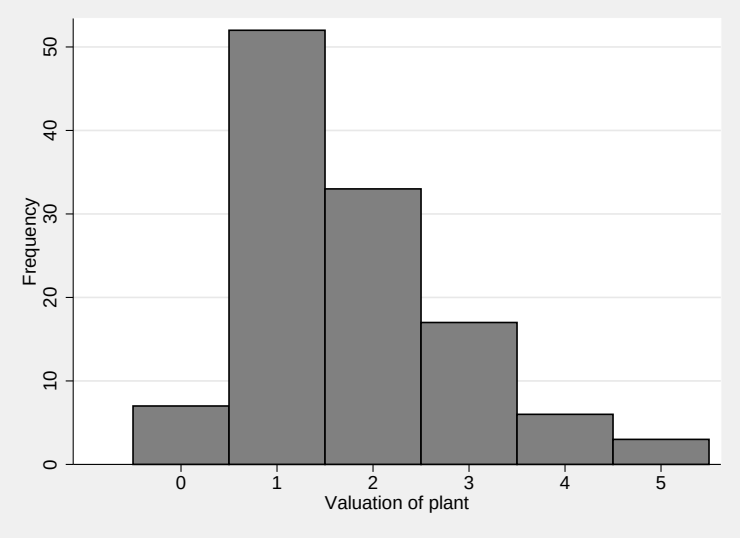
Figure A.1: COGNITIVE REFLECTION TEST (CRT)



Notes: The figure displays the frequency with which the CRT questions are answered correctly. The subjects in category 0 did not answer any of the questions correctly, while those in category 1 replied to one of the CRT questions correctly, those in category 2 answered 2 questions correctly and those in category 3 answered all 3 questions correctly.

A.2.2 Valuation of Environmental Instrument

Figure A.2: VALUATION OF PLANTS



Notes: The figure below shows the frequency with which subjects chose the relevant valuation brackets when asked to disclose how much they were willing to pay to contribute one additional plant to the environmental project. Those in category 0 replied that they did not wish to contribute any money at all, those in category 1 stated they would contribute between £0.50 and £2.50, those in category 2 picked the £2.50 to £5.00 bracket, those in category 3 said they would contribute between £5.50 to £10.00, category 4 picked the £10.50 and £15.00 bracket while the final group in category 5 stated that they would be willing to pay £15.50 and over to add one plant to the project.

A.2.3 Domain Effect in Discounting

Table A.5: FIXED EFFECTS OLS

VARIABLES	hypDP
Domain	0.159
	(0.118)
Constant	1.870***
	(0.0834)
Observations	638
Number of ID	108
R-squared	0.003

Notes: The table presents the results of the Fixed Effects OLS regression of the hyperbolic discount rate parameters elicited on the domain dummy which takes the value of 1 when the question was on the environmental domain.

A.3 Experimental Instructions for Chapter 3

This document consists of the instructions given to subjects during the experiment. There were four groups of subjects that undertook the experiment. Groups A and B were presented with the incentivised version of the experiment, while groups C and D were presented with the hypothetical version. Each group was presented with all the seven tasks described below, however the order in which these tasks were presented differed. Group A were presented with the incentivised Monetary Discounting and Risk Aversion tasks first, followed by the incentivised Environmental Discounting and Risk Aversions tasks. Group B were presented with the incentivised Environmental Discounting and Risk Aversion tasks first, followed by the incentivised Monetary Discounting and Risk Aversion tasks. Group C were presented with the hypothetical Monetary Discounting and Risk Aversion tasks first followed by the hypothetical Environmental Discounting and Risk Aversion tasks. Finally, Group D were presented with the hypothetical Environmental Discounting and Risk Aversion tasks first, followed by the hypothetical Monetary Discounting and Risk Aversion tasks. After these first four tasks were compelted, each group was also presented with the following tasks in the same order: the Cognitive Reflection Test and the Questionnaire.

The Experimental Instructions for each of the groups are analogous except that those presented with the hypothetical scenarios, Groups C and D, were not given any information about payoffs with the exception of the participation fee and were informed that the choices were hypothetical. The only other difference betwee the four groups, groups A, B, C and D, is the order in which the first two tasks were presented. The titles of the stages were omitted from the experimental instructions given to subjects.

Instructions for the Incentivised Treatment

The purpose of this experimental session is to study how people make decisions in a particular situation.

The experimental session consists of **seven** stages to be described at the appropriate time.

The instructions are the same for all participants.

For your participation in the experimental session, you will receive a £5 as a participation fee. In addition, you will have the opportunity to increase your earnings.

At the end of the session, when all the participants have completed all seven stages, you will be paid your total earnings. Your total earnings will be placed in a payment envelope. The instructions are simple, yet if you have a question please raise your hand. Aside from these questions, any communication with other participants or looking at other participants' screens is not permitted and will lead to your immediate exclusion from the experiment.

All information collected during the experiment will be kept **strictly confidential** and data will be handled in line with the Data Protection Act 1998.

If you would like further clarification, please raise your hand and the experimenter will come by shortly to answer your questions, otherwise please click the Next button.

Monetary Discounting

Stage 1

Your responses in this Stage might be selected for payment.

This Stage consists of three blocks of 6 questions in each block for a total of 18 questions. The questions will require you to make a choice between a smaller monetary outcome occurring at one point in time and another larger monetary outcome occurring at a later point in time. The time delay is identical **within** each block but will change **between** blocks.

Example

Please select which of the following you prefer:

£50 payable in 1 month from today.

£55 payable in 7 months from today.

If you would like further clarification, please raise your hand and the experimenter will come by shortly to answer your questions, otherwise please click the Next button.

[The following choices were displayed one by one on the subjects' screens.]

Table A.6: BINARY CHOICES PRESENTED IN MD

Binary Choice	
Smaller Sooner	Larger Later
£50	£55
£50	£60
£50	£65
£50	£70
£50	£75
£50	£100

Notes: In the first column, we present the smaller sooner amount, which is the amount that would be available to subjects after the one month front-end delay, while in the second column, we present the larger later amount, which is the amount that would be available to subjects after the specified delay period. Subjects answered three sets of these six questions, one for each of the time-delay periods: (i) the 3-month delay period, (ii) the 6-month delay period, and (iii) the 12-month delay period.

As indicated earlier, your responses in this Stage might be selected for payment at the end of the experimental session. Here is how.

A participant in the lab today will be selected at the end of the experimental session using the bingo machine on the side. Each participant has an equal chance of being selected.

The selected participant will face another two draws. The first draw will determine the Stage (either Stage 1 or Stage 3), and the second will identify one specific question from the selected Stage. All the draws will be carried out using the bingo machine.

Recall that you will respond to a total of 18 questions in this Stage (3 blocks of six questions in each block), and will answer another 18 questions in Stage 3. Based on the selected participant's response in the specific question drawn, the selected participant will get paid.

For example, assume you are the selected participant, this Stage was drawn, and in the specific question drawn you had responded that you would rather have £X in Y months. Then, the experimenter will put a completed **Requisition Form** for £X with the payment date in Y months' time in your payment envelope.

Note: A **Requisition Form** is an official request for payment that can be submitted to the University of Southampton. Requisition Forms will be paid on the date specified in the question (in this example in Y months' time) provided you fill in the necessary details on the form.

If you would like further clarification, please raise your hand and the experimenter will come by shortly to answer your questions, otherwise please click the Next button.

Monetary Risk Aversion Test

Stage 2

Your response in this Stage might be selected for payment.

In this part of the study, you are asked to choose one of the five options shown below. Regardless of which option you choose, there are two possible outcomes (Outcome X and Outcome Y). These outcomes are equally likely in all five options - there is a 50% chance of Outcome X and a 50% chance of Outcome Y, just like the flip of a coin. The options differ only in how much each outcome pays.

If you would like further clarification, please raise your hand and the experimenter will come by shortly to answer your questions, otherwise please click the Next button.

[The following options were displayed to subjects in the same format as shown below.]

Table A.7: OPTIONS PRESENTED IN MRAT

Option	Outcome	Payoffs (£)	Probability
1	X	50.00	50%
	Y	50.00	50%
2	X	35.00	50%
	Y	87.50	50%
3	X	25.00	50%
	Y	112.50	50%
4	X	15.00	50%
	Y	137.50	50%
5	X	5.00	50%
	Y	162.50	50%

Notes: In the first column, we list the 5 options available to subjects. In the second column, we list the possible outcomes of each option: Outcome X or Outcome Y. In the third column, we list the payoffs associated with each outcome in each option, and in column four, we list the probability of that specific outcome occurring given the subject picked that option.

As indicated earlier, your response in this Stage might be selected for payment at the end of the experimental session. Here is how.

A participant in the lab today will be selected at the end of the experimental session using the bingo machine on the side. Each participant has an equal chance of being selected.

The selected participant will face another two draws. The first draw will determine the Stage (either Stage 2 or Stage 4), and the second will identify the outcome (either Outcome X or Outcome Y). All the draws will be carried out using the bingo machine.

You will choose one option in this Stage and one option in Stage 4. The selected participant will be paid based on the stage drawn, the outcome drawn, and the selected participant's option choice.

For example, assume you are the selected participant, this stage is drawn, and you chose Option 2; then, you will either earn £35 if Outcome X occurs or £87.50 if Outcome Y occurs. If you chose Option 4, then, you will either earn £15 if Outcome X occurs or £137.50 if Outcome Y occurs. The experimenter will put a completed Requisition Form for your earnings with today's date as the payment date in your payment envelope.

You will only find out the outcome at the end of the experimental session. The options will be displayed again when you begin the Stage.

If you would like further clarification, please raise your hand and the experimenter will come by shortly to answer your questions, otherwise please click the Next button.

Environmental Discounting

Stage 3

Your responses in this Stage might be selected for payment.

An Environmental Project is going to be carried out at the University of Southampton between April 2014 and April 2015. The project has been sponsored by various grants.

On four separate occasions, volunteers will be distributing free, bee-friendly plants to staff and students at the University's Highfield campus.

The plants will be chosen depending on the time of year they are to be planted, in order to ensure that they are immediately beneficial to bees, and to require little care outside of the original planting.

Bees are behind much of the food we eat as they pollinate the plants that produce most of our fruit and vegetables. Bees, however, face numerous threats and their numbers are declining due to changes in land use, building projects, pesticides, pollution and climate change.

Small changes, such as planting nectar-rich flowers, can help restore bee populations. Bee-friendly plants can attract up to 100 times as many bees. Feeding havens in the middle of an urban jungle have great value. The project will help create bee-friendly communities.

In this stage, the choices you make will increase the number of plants distributed in this project.

If you would like further clarification, please raise your hand and the experimenter will come by shortly to answer your questions, otherwise please click the Next button.

This Stage also consists of three blocks of 6 questions in each block for a total of 18 questions. The questions will require you to make a choice between a smaller environmental outcome occurring at one point in time and another larger environmental outcome occurring at a later point in time. The time delay is identical **within** each block but will change **between** blocks.

Example
Please select which of the following you prefer:

10 plants that will be distributed in 1 month from today.

11 plants that will be distributed in 7 months from today.

If you would like further clarification, please raise your hand and the experimenter will come by shortly to answer your questions, otherwise please click the Next button.

[The following choices were displayed one by one on the subjects' screens.]

Table A.8: BINARY CHOICES PRESENTED IN ED

Binary Choice	
Smaller Sooner	Larger Later
10 plants	11 plants
10 plants	12 plants
10 plants	13 plants
10 plants	14 plants
10 plants	15 plants
10 plants	20 plants

Notes: In the first column, we present the smaller sooner amount, which is the amount that would be available to subjects after the one month front-end delay, while in the second column, we present the larger later amount, which is the amount that would be available to subjects after the specified delay period. Subjects answered three sets of these six questions, one for each of the time-delay periods: (i) the 3-month delay period, (ii) the 6-month delay period, and (iii) the 12-month delay period.

As indicated earlier, your responses in this Stage might be selected for payment at the end of the experimental session. Here is how.

As was explained in Stage 1, a participant in the lab today will be selected at the end of the experimental session using the bingo machine on the side. Each participant has an equal chance of being selected.

The selected participant will face another two draws. The first draw will determine the Stage (either Stage 1 or Stage 3), and the second will identify one specific question from the selected Stage. All the draws will be carried out using the bingo machine.

Recall that you will respond to a total of 18 questions in this Stage (3 blocks of six questions in each block), and have already answered another 18 questions in Stage 1. Based on the selected participant's response in the specific question drawn, the selected participant will get paid.

For example, assume you are the selected participant, this Stage was drawn, and in the specific question drawn you had responded that you would rather have X plants in Y months. Then, the experimenter will add X plants to the environmental project and they will be distributed on campus in Y months' time. You will be informed in advance about the exact project date and you may choose to receive an email update about the event.

If you would like further clarification, please raise your hand and the experimenter will come by shortly to answer your questions, otherwise please click the Next button.

Environmental Risk Aversion Test

Stage 4

Your response in this Stage might be selected for payment.

In this part of the study, you are asked to choose one of the five options shown below. Regardless of which option you choose, there are two possible outcomes (Outcome X and Outcome Y). These outcomes are equally likely in all five options - there is a 50% chance of Outcome X and a 50% chance of Outcome Y, just like the flip of a coin. The options differ only in how much each outcome pays.

If you would like further clarification, please raise your hand and the experimenter will come by shortly to answer your questions, otherwise please click the Next button.

[The following options were displayed to subjects in the same format as shown below.]

Table A.9: OPTIONS PRESENTED IN ERAT

Option	Outcome	Payoffs (plants)	Probability
1	X	10 plants	50%
	Y	10 plants	50%
2	X	7 plants	50%
	Y	18 plants	50%
3	X	5 plants	50%
	Y	23 plants	50%
4	X	3 plants	50%
	Y	28 plants	50%
5	X	1 plant	50%
	Y	33 plants	50%

Notes: In the first column, we list the 5 options available to subjects. In the second column, we list the possible outcomes of each option: Outcome X or Outcome Y. In the third column, we list the payoffs (in plants) associated with each outcome in each option, and in column four, we list the probability of that specific outcome occurring given the subject picked that option.

As indicated earlier, your response in this Stage might be selected for payment at the end of the experimental session. Here is how.

As was explained in Stage 2, a participant in the session today will be selected at the end of the experimental session using the bingo machine on the side. Each participant has an equal chance of being selected.

The selected participant will face another two draws. The first draw will determine the Stage (either Stage 2 or Stage 4), and the second will identify the outcome (either Outcome X or Outcome Y). All the draws will be carried out using the bingo machine.

You will choose one option in this Stage, and have already chosen one option in Stage 2. The selected participant will be paid based on the stage drawn, the outcome drawn, and the selected participant's option choice.

For example, assume you are the selected participant, this Stage is drawn, and you choose Option 2; then, you will either get 7 plants if Outcome X occurs or 18 plants if Outcome Y occurs. If you choose Option 4, then, you will either get 3 plants if Outcome X occurs or 28 plants if Outcome Y occurs. These plants will be added to the environmental project.

You will only find out the outcome at the end of the experimental session. The options will be displayed again when you begin the Stage.

If you would like further clarification, please raise your hand and the experimenter will come by shortly to answer your questions, otherwise please click the Next button.

Instructions for the Hypothetical Treatment

The purpose of this experimental session is to study how people make decisions in a particular situation.

The experimental session consists of **seven** stages to be described at the appropriate time.

The instructions are the same for all participants.

For your participation in the experimental session, you will receive a £5 as a participation fee.

At the end of the session, when all the participants have completed all seven stages, you will be paid your show up fee, which will be placed in payment envelopes. The instructions are simple, yet if you have a question please raise your hand. Aside from these questions, any communication with other participants or looking at other participants' screens is not permitted and will lead to your immediate exclusion from the experiment.

All information collected during the experiment will be kept **strictly confidential** and data will be handled in line with the Data Protection Act 1998.

If you would like further clarification, please raise your hand and the experimenter will come by shortly to answer your questions, otherwise please click the Next button.

Monetary Discounting

Stage 1

This Stage consists of three blocks of 6 questions in each block for a total of 18 questions. The questions will require you to make a choice between a smaller monetary outcome occurring at one point in time and another larger monetary outcome occurring at a later point in time. The time delay is identical **within** each block but will change **between** blocks.

Example
Please select which of the following you prefer:

£50 payable in 1 month from today.

£55 payable in 7 months from today.

If you would like further clarification, please raise your hand and the experimenter will come by shortly to answer your questions, otherwise please click the Next button.

[The following choices were displayed one by one on the subjects' screens.]

Table A.10: BINARY CHOICES PRESENTED IN MD

Binary Choice	
Smaller Sooner	Larger Later
£50	£55
£50	£60
£50	£65
£50	£70
£50	£75
£50	£100

Notes: In the first column, we present the smaller sooner amount, which is the amount that would be available to subjects after the one month front-end delay, while in the second column, we present the larger later amount, which is the amount that would be available to subjects after the specified delay period. Subjects answered three sets of these six questions, one for each of the time-delay periods: (i) the 3-month delay period, (ii) the 6-month delay period, and (iii) the 12-month delay period.

Monetary Risk Aversion Test

Stage 2

In this part of the study, you are asked to choose one of the five options shown below. Regardless of which option you choose, there are two possible outcomes (Outcome X and Outcome Y). These outcomes are equally likely in all five options - there is a 50% chance of Outcome X and a 50% chance of Outcome Y, just like the flip of a coin. The options differ only in how much each outcome pays.

If you would like further clarification, please raise your hand and the experimenter will

come by shortly to answer your questions, otherwise please click the Next button.

[The following options were displayed to subjects in the same format as shown below.]

Table A.11: OPTIONS PRESENTED IN MRAT

Option	Outcome	Payoffs (£)	Probability
1	X	50.00	50%
	Y	50.00	50%
2	X	35.00	50%
	Y	87.50	50%
3	X	25.00	50%
	Y	112.50	50%
4	X	15.00	50%
	Y	137.50	50%
5	X	5.00	50%
	Y	162.50	50%

Notes: In the first column, we list the 5 options available to subjects. In the second column, we list the possible outcomes of each option: Outcome X or Outcome Y. In the third column, we list the payoffs associated with each outcome in each option, and in column four, we list the probability of that specific outcome occurring given the subject picked that option.

Environmental Discounting

Stage 3

Imagine an Environmental Project is going to be carried out at the University of Southampton between April 2014 and April 2015. The project would been sponsored by various grants.

On four separate occasions, volunteers will be distributing free, bee-friendly plants to staff and students at the University's Highfield campus.

The plants will be chosen depending on the time of year they are to be planted, in order to ensure that they are immediately beneficial to bees, and to require little care outside of the original planting.

Bees are behind much of the food we eat as they pollinate the plants that produce most of our fruit and vegetables. Bees, however, face numerous threats and their numbers are declining due to changes in land use, building projects, pesticides, pollution and climate change.

Small changes, such as planting nectar-rich flowers, can help restore bee populations. Bee-friendly plants can attract up to 100 times as many bees. Feeding havens in the middle of an urban jungle have great value. The project will help create bee-friendly communities.

In this stage, the choices you make will increase the number of plants distributed in this project.

If you would like further clarification, please raise your hand and the experimenter will come by shortly to answer your questions, otherwise please click the Next button.

This Stage also consists of three blocks of 6 questions in each block for a total of 18 questions. The questions will require you to make a choice between a smaller environmental outcome occurring at one point in time and another larger environmental outcome occurring at a later point in time. The time delay is identical **within** each block but will change **between** blocks.

Example
Please select which of the following you prefer:

10 plants that will be distributed in 1 month from today.

11 plants that will be distributed in 7 months from today.

If you would like further clarification, please raise your hand and the experimenter will come by shortly to answer your questions, otherwise please click the Next button.

[The following choices were displayed one by one on the subjects' screens.]

Table A.12: BINARY CHOICES PRESENTED IN ED

Binary Choice	
Smaller Sooner	Larger Later
10 plants	11 plants
10 plants	12 plants
10 plants	13 plants
10 plants	14 plants
10 plants	15 plants
10 plants	20 plants

Notes: In the first column, we present the smaller sooner amount, which is the amount that would be available to subjects after the one month front-end delay, while in the second column, we present the larger later amount, which is the amount that would be available to subjects after the specified delay period. Subjects answered three sets of these six questions, one for each of the time-delay periods: (i) the 3-month delay period, (ii) the 6-month delay period, and (iii) the 12-month delay period.

Environmental Risk Aversion Test

Stage 4

In this part of the study, you are asked to choose one of the five options shown below. Regardless of which option you choose, there are two possible outcomes (Outcome X and Outcome Y). These outcomes are equally likely in all five options - there is a 50% chance of Outcome X and a 50% chance of Outcome Y, just like the flip of a coin. The options differ only in how much each outcome pays.

If you would like further clarification, please raise your hand and the experimenter will

come by shortly to answer your questions, otherwise please click the Next button.

[The following options were displayed to subjects in the same format as shown below.]

Table A.13: OPTIONS PRESENTED IN ERAT

Option	Outcome	Payoffs (plants)	Probability
1	X	10 plants	50%
	Y	10 plants	50%
2	X	7 plants	50%
	Y	18 plants	50%
3	X	5 plants	50%
	Y	23 plants	50%
4	X	3 plants	50%
	Y	28 plants	50%
5	X	1 plant	50%
	Y	33 plants	50%

Notes: In the first column, we list the 5 options available to subjects. In the second column, we list the possible outcomes of each option: Outcome X or Outcome Y. In the third column, we list the payoffs (in plants) associated with each outcome in each option, and in column four, we list the probability of that specific outcome occurring given the subject picked that option.

Cognitive Reflection Test

Stage 5

In this part of the study you are asked to respond to three questions. Please choose your option by clicking on a radio button. You will be asked to confirm your choice before you move to the next screen.

If you would like further clarification, please raise your hand and the experimenter will come by shortly to answer your questions, otherwise please click the Next button.

- A bat and a ball cost $\pounds 1.10$ in total. The bat costs $\pounds 1.00$ more than the ball. How much does the ball cost?

  A. $\pounds 0.10$
  B. $\pounds 0.05$
  C. $\pounds 0.02$
  D. $\pounds 0.08$

- If it takes 5 machines, 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?

  A. 5 minutes
  B. 6 minutes
  C. 100 minutes
  D. 10 minutes

- In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake?

A. 37 days

B. 24 days

C. 42 days

D. 47 days

Environment Questionnaire

Stage 6

In this part of the study, you are asked to respond to questions of an environmental nature.

Please choose your option by clicking on a radio button.

If you would like further clarification, please raise your hand and an experimental assistant will come by shortly to answer your questions, otherwise please click the Next button.

Valuation Question

Imagine you are given a one-off opportunity to sponsor a plant to be added to this project. How much would you be willing to pay for one bee-friendly plant?

- £0.00
- £0.50 - £2.50
- £2.50 - £5.00
- £5.50 - £10.00
- £10.50 - £15.00
- £15.50 and above

Environmental Statements

I would only travel by bus if I had no other choice.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

For the sake of the environment, car users should pay higher taxes.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

People who fly should bear the cost of the environmental damage that air travel causes.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree

- Strongly disagree
- Don't know

I don't pay much attention to the amount of water I use at home.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

People have a duty to recycle.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

We are close to the limit of the number of people the earth can support.

- Strongly agree
- Tend to agree
- Neither agree nor disagree

- Tend to disagree
- Strongly disagree
- Don't know

The Earth has very limited room and resources.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

If things continue on their current course, we will soon experience a major environmental disaster.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

The so-called 'environmental crisis' facing humanity has been greatly exaggerated.

- Strongly agree

- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

It would embarrass me if my friends thought my lifestyle was purposefully environmentally friendly.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

Being green is an alternative lifestyle, it's not for the majority.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

I find it hard to change my habits to be more environmentally friendly.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

It's only worth doing environmentally-friendly things if they save you money.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

The effects of climate change are too far in the future to really worry me.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

It's not worth me doing things to help the environment if others don't do the same.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

It's not worth Britain trying to combat climate change, because other countries will just cancel what we do.

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don't know

Which of these best describes how you feel about your current lifestyle and the environment?

- I'd like to do a lot more to help the environment
- I'd like to do a bit more to help the environment
- I'm happy with what I do at the moment

- Don’t Know

Questionnaire

Stage 7

In this part of the study you will complete a questionnaire. The questionnaire asks you to answer some questions about yourself. You will always have the option to not answer a question if you don't wish to provide some information. Failure to provide information will NOT affect your ability to participate in the remainder of the experiment.

1. What is your age?

2. What is your gender?

Male

Female

Prefer not to answer

3. On average, in a typical month, how much do you spend on non-accommodation expenses? (Please count the total expenditure on food, entertainment, clothes, mobile phone bills, and transport, but exclude rent/mortgage repayment)

4. Do your parents own or rent the house in which they now live?

Own

Rent

Prefer not to answer

A.4 Supplementary Tables and Charts to Chapter 3

A.4.1 Kruskal-Wallis H tests

Table A.14: KRUSKAL-WALLIS H TESTS

VARIABLES	p-value
Age	0.4344
Female	0.6323
Home Own.	0.1508
Monthly Exp.	0.6582
Valuation	0.2172
CRT	0.6788

Notes: The table presents the results of the Kruskal-Wallis H tests, a non-parametric test that is used to determine if there are statistically significant differences between the four groups on the variables elicited.

A.4.2 Table 3.5 Full Results

Table A.15: TABLE 3.5 FULL RESULTS: ESTIMATION RESULTS FOR RISK AVERSION TASKS

	Both Goods	Money	Environment
	Group A, B, C & D	Group A & C	Group B & D
Mean			
Real	0.220	0.233	0.277
	(0.699)	(0.728)	(0.682)
Environment	-0.112		
	(0.610)		
Real × Env	0.0833		
	(1.089)		
Age	0.0785	0.173	-0.0682
	(0.149)	(0.191)	(0.197)
Sex	-1.112**	-0.771	-1.498*
	(0.533)	(0.657)	(0.768)
Monthly Exp.	0.000992	0.00181	-0.000235
	(0.00187)	(0.00209)	(0.00281)
Home Own.	0.243	-0.0879	0.911
	(0.632)	(0.774)	(0.958)
HighCRT	0.541	0.385	0.409
	(0.593)	(0.753)	(0.710)
Green	0.0342	0.351	-0.235
	(0.551)	(0.708)	(0.692)
Highvalue	-0.268	-0.822	0.531
	(0.652)	(0.763)	(0.799)
Variance			
Real	0.0419	0.0227	0.470
	(0.370)	(0.413)	(0.376)
Environment	0.445		
	(0.331)		
Real × Env	0.141		
	(0.513)		
Subjects	102	44	58

Notes: The results obtained from ordered probit regression models are displayed above. The results of the merged data for both goods is in column 1, while column 2 and 3 display the individual results for the two goods. Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

A.4.3 Table 3.7 Full Results

Table A.16: TABLE 3.7 FULL RESULTS: ESTIMATION RESULTS FOR DISCOUNTING TASKS

	Both Goods	Money	Environment
	Group A, B, C & D	Group A & C	Group B & D
Mean			
Real	0.251	0.323	-0.851**
	(0.594)	(0.607)	(0.418)
Environment	0.667		
	(0.412)		
Reall#Env	-1.036		
	(0.729)		
Age	0.109	0.0989	0.178
	(0.0794)	(0.0936)	(0.117)
Sex	0.277	0.479	-0.137
	(0.247)	(0.305)	(0.407)
Monthly Exp.	0.000578	0.00118*	-0.000896
	(0.000752)	(0.000691)	(0.00147)
Home Own.	-0.496*	-0.525	-0.295
	(0.255)	(0.350)	(0.439)
HighCRT	0.112	0.0826	0.242
	(0.241)	(0.308)	(0.358)
Green	-0.549*	-0.475	-0.879**
	(0.314)	(0.344)	(0.433)
Highvalue	0.812***	0.920**	0.352
	(0.298)	(0.358)	(0.514)
Variance			
Real	0.867**	0.929***	-0.552**
	(0.360)	(0.343)	(0.278)
Environment	0.978***		
	(0.248)		
Real × Env	-1.379***		
	(0.437)		
Constant	-0.266	-0.287*	0.672***
	(0.173)	(0.168)	(0.200)
Subjects	96	42	54

Notes: The results obtained from interval regression models are displayed above. The results of the merged data for both goods is in column 1, while column 2 and 3 display the individual results for the two goods. Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

A.4.4 Note on Identification

With three attributes of two levels and one of three levels the full factorial for the linear design has 24 combinations. To turn this into a choice design, the full factorial was used in assigning the first of the two alternatives in each choice set with random allocation (out of the 24 choice sets without replacement) for the assignment of the second alternative. This manual approach is the simplest in creating choice sets and impose any design restrictions. Restrictions were necessary, in this case, due to the presence of dominances within choice sets. This random allocation with constraints theoretically affects design efficiency but not the identification of its parameters (i.e. 24 choice sets with 23 degrees of freedom required for estimation without a constant).

Unfortunately, the manual handling of the design was not perfectly successful and resulted in a design whose 4-way interactions are not identified when all 23 possible parameters are to be estimated (i.e. full categorical analysis of the attributes). Nevertheless, given the linear consideration of delay in the econometric specification that is of interest in the Chapter, all parameters of the specification are identified, inclusive of the 4-way interaction. A small simulation exercise, with 500 individuals and 150 repetitions confirms this (see Table below).

Table A.17: IDENTIFICATION SIMULATION

	True parameter	Beta	[95% Conf.	Interval]
Outcome	0.20	0.206	0.188	0.224
Magnitude	0.20	0.207	0.187	0.227
Delay	0.20	0.2	0.196	0.204
Domain	0.20	0.198	0.181	0.214
Outcome#Magnitude	-0.20	-0.211	-0.232	-0.189
Outcome#Delay	-0.20	-0.2	-0.207	-0.194
Outcome#Domain	-0.20	-0.201	-0.223	-0.178
Magnitude#Delay	-0.20	-0.2	-0.206	-0.194
Magnitude#Domain	-0.20	-0.203	-0.236	-0.169
Delay#Domain	-0.20	-0.199	-0.204	-0.193
Outcome#Magnitude#Delay	0.20	0.202	0.194	0.21
Outcome#Magnitude#Domain	0.20	0.191	0.154	0.228
Outcome#Delay#Domain	0.20	0.198	0.191	0.204
Magnitude#Delay#Domain	0.20	0.199	0.189	0.209
Outcome#Magnitude#Delay#Domain	-0.20	-0.194	-0.206	-0.183

Notes: The results obtained from the simulation exercise are displayed above.

A.5 Experimental Instructions for Chapter 4

This document consists of the instructions given to subjects during the online experiment. The experiment was divided into two parts, Part 1 and Part 2. Part 1 consisted of a calibration exercise where subjects were informed of a health and an environment project and were asked to decide to allocate a total of 200 people to the two projects. Using this calibration value we then divided subjects into 11 groups of subjects with similar calibration values and presented each group with a version of Part 2 of the experiment that matched their calibration.

Both parts were administered using the SurveyMonkey platform and subjects were recruited through the Prolific Academic database. The two parts were collected a week apart.

A.5.1 Instructions for Part 1

Consent

You have been asked to participate in this study because you are on the Prolific Academic Research Database. This study is made up of two surveys. The first one that you are accessing today should take 3 minutes. The second part will be released in 1 weeks' time, this will take 15 minutes and have a higher payment accordingly. If you are unwilling to take the second survey next week please do not complete this one.

This survey is partially funded by the ESRC and the Faculty of Social, Human and Mathematical Sciences at the University of Southampton. Your responses will be anonymous, which means they will not be linked to your name or other details that can identify you as the respondent. The researcher will only be able to access this anonymous data and it will be handled in compliance with the Data Protection Act and University of Southampton policy.

If you have any questions about this survey or the study please contact the lead researcher on j.sadeh@soton.ac.uk. In the unlikely case of concern or complaint, you can contact the Research Integrity and Governance Manager on 023 8059 5058, or rgoinfo@soton.ac.uk. Ethics approval reference: 23388

Thank you for taking the time to read the information sheet and for considering taking part in the research. If you are ready to take part please answer the question below to indicate your consent, and the survey will start.

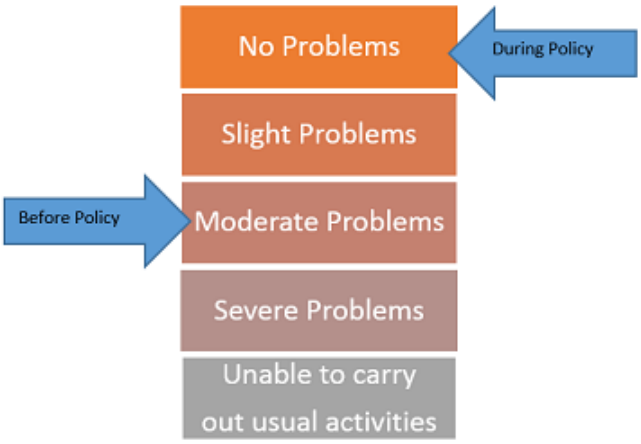
Calibration Exercise

For the purposes of this survey you are being asked to imagine you are a representative on a local council of a nearby locality that is not your own and must make decisions in the interest of the people living in that locality. The following paragraphs will describe two policies, a health policy and an environmental policy. Please read all the information provided about these two policies. At the end of the descriptions you will only have one question to answer.

The Health Policy

There are a number of people in this locality whose health is currently as follows: they have some problems in walking, difficulties when dressing or washing themselves and carrying out day to day activities such as working, studying or domestic tasks. They also suffer a certain amount of pain or inconvenience and feel moderately anxious or depressed. A budget surplus can be used to fund a new health intervention that will allow these individuals to benefit from a temporary improvement in their condition. During the time of the improvement the symptoms described above will no longer be felt, which means that they will be in near perfect health.

Figure A.3: HEALTH VISUAL



Notes: The visual above was presented as an aide to facilitate the comparison between the current status quo and the hypothetical impact of the health project being proposed.

The Environment Policy

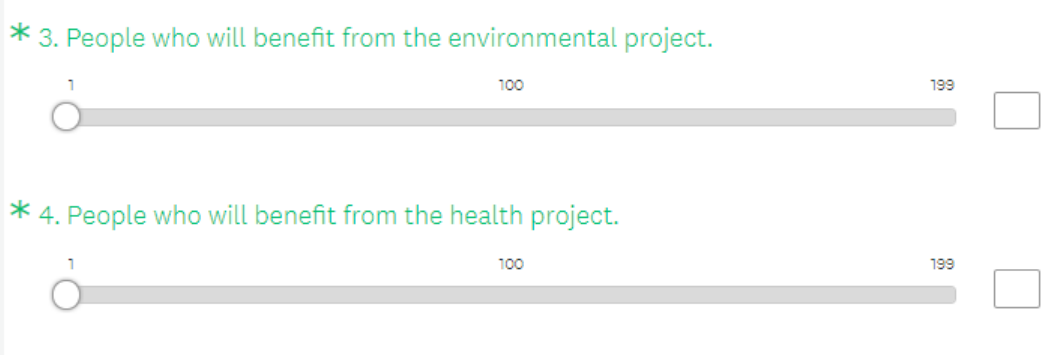
There are a number of commercial activities being undertaken in this locality that generate air pollution and reduce the air quality for a number of people in the area. Poor air quality causes damage to plants and animals, affecting biodiversity and crop yields, it lowers property prices for residences in the area, and may cause respiratory issues in people with poor health. The current air quality is set at 125 on the Air Quality Index [an index measuring air quality where 0 represents a low level of pollution and 300 represents a very high level of pollution]. A budget surplus can be used to fund an environmental intervention that will allow these individuals to benefit from a temporary improvement in air quality. During the time of the improvement the air quality level would be 1.

Figure A.4: ENVIRONMENT VISUAL

Notes: The visual above was presented as an aide to facilitate the comparison between the current status quo and the hypothetical impact of the environment project being proposed.

There are only enough funds to ensure that a total of 200 people benefit from both council projects. Now that you know all about the two projects, you need to decide how many people will benefit from each one. You need to slide the slider button to reach the chosen number of people for each project. The total number of people who can benefit, however, must be 200. This means that the sum of the number displayed in the first box and the second box on the right hand side must add up to 200. Both projects must run, so at least 1 person must benefit from each of the projects. If you are struggling to get a specific number to display you can always input your preferred number directly into the box.

Figure A.5: SLIDER CALIBRATION QUESTION



Notes: The image above displayes the slider used for the calibration exercise.

A.5.2 Instructions for Part 2

Consent

You have been asked to participate in this study because you participated in the first part of the study sent out last week. The survey should take a maximum of 15 minutes. It is important that you finish the entire survey in one go. If you are unable to do so at the moment, please return to the site when you have sufficient time to undertake it. There will be no further follow up contact from us following your submission of survey responses.

Your responses will be anonymous, which means they will not be linked to your name or other details that can identify you as the respondent. The researcher will only be able to access this anonymous data and it will be handled in compliance with the Data Protection Act and University of Southampton policy.

This survey is partially funded by the ESRC and the Faculty of Social, Human and Mathematical Sciences at the University of Southampton.

If you have any questions about this survey or the study please contact the lead researcher on j.sadeh@soton.ac.uk. In the unlikely case of concern or complaint, you can contact the Research Integrity and Governance Manager on 023 8059 5058, or rgoinfo@soton.ac.uk. Ethics approval reference: 23388

Thank you for taking the time to read the information sheet and for considering taking part in the research. If you are ready to take part please answer the question below to indicate your consent, and the survey will start.

Introduction Page 1

For the purposes of this survey you are being asked to imagine you are a representative on a local council of a nearby locality that is not your own and must make decisions in the interest of the people living in that locality. In each survey page you will be presented with two different policies, sometimes these will be health policies, sometimes these will be environment policies. You will be given information about each one and asked to pick your preferred policy. The individuals affected by the two policies are identical in all other aspects except those outlined in the description. The general description of the health and environment policies will remain the same throughout the survey. What will change is when the policy will start and the length of time the policy will run for.

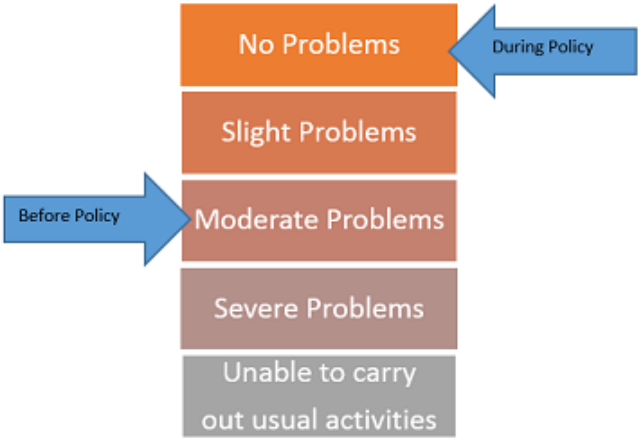
Introduction Page 2

The general description of the health and environment policies will remain the same throughout the survey. These descriptions are provided below. You will be able to access these descriptions through links provided in each question.

The Health Policy

There are a number of people in this locality whose health is currently as follows: they have some problems in walking, difficulties when dressing or washing themselves and carrying out day to day activities such as working, studying or domestic tasks. They also suffer a certain amount of pain or inconvenience and feel moderately anxious or depressed. A budget surplus can be used to fund a new health intervention that will allow these individuals to benefit from a temporary improvement in their condition. During the time of the improvement the symptoms described above will no longer be felt, which means that they will be in near perfect health.

Figure A.6: HEALTH VISUAL



Notes: The visual above was presented as an aide to facilitate the comparison between the current status quo and the hypothetical impact of the health project being proposed.

The Environment Policy

There are a number of commercial activities being undertaken in this locality that generate air pollution and reduce the air quality for a number of people in the area. Poor air quality causes damage to plants and animals, affecting biodiversity and crop yields, it lowers property prices for residences in the area, and may cause respiratory issues in people with poor health. The current air quality is set at 125 on the Air Quality Index [an index measuring air quality where 0 represents a low level of pollution and 300 represents a very high level of pollution]. A budget surplus can be used to fund an environmental intervention that will allow these individuals to benefit from a temporary improvement in air quality. During the time of the improvement the air quality level would be 1.

Figure A.7: ENVIRONMENT VISUAL

Notes: The visual above was presented as an aide to facilitate the comparison between the current status quo and the hypothetical impact of the environment project being proposed.

What will change is the key information. This will include the following.

When the policy will start: This is the time when the benefits will start being felt by these people. Before this time things will remain are they are currently described.

The length of time the policy will run for: This is the number of weeks that these people will enjoy the benefit for.

Introduction Page 3

This page is an example of what the survey pages will look like.

Figure A.8: PRACTICE QUESTION

You can click on the links if you need to be reminded of the details of each policy.

After you have read this information you must evaluate the two options and then make your choice.

Once you leave a page you will not be able to go back, so only click Next when you are sure of your answer.

Introduction Page 4

The survey will now begin.

Before you start making choices remember that you are a representative on a local council of a nearby locality that is not your own and must make decisions in the interest of the people living in that locality. The council has a budget surplus this year that it can use on only one of two projects. You will be presented with a sequence of two possible projects and you must pick the project that you think is the best from each set. You should pick this based on what would be in the best interest of the community, disregarding any personal benefit that you yourself could gain from either of the scenarios. The projects will differ on how many people are impacted, by the type of project, by how long they will be producing a benefit, and by when they are expected to start producing this benefit.

Main Body of Experiment

Participants were presented with 24 choice sets with two different scenarios in each choice set. The layout for each scenario is identical to the practice question above, the main things that changed between participants is the number of people affected which was dependent on their personal calibration in Part 1. The main things that changed from question to question were the number of weeks the benefit would run for and when it would start. The 24 questions presented are summarised in Table A.18 below.

Table A.18: CHOICE SETS PRESENTED

Choice Set	Alternative A			Alternative B		
	Domain	Length of Benefit (weeks)	Delay (years)	Domain	Length of Benefit (weeks)	Delay (years)
1	Environment	118	2	Environment	161	5
2	Environment	161	5	Environment	21	2
3	Environment	118	5	Health	21	1
4	Health	21	5	Health	16	1
5	Health	21	1	Environment	21	1
6	Health	16	1	Environment	21	5
7	Environment	21	1	Health	16	5
8	Environment	161	2	Health	118	1
9	Environment	16	2	Health	118	5
10	Environment	161	5	Environment	161	2
11	Health	161	1	Environment	118	1
12	Health	16	5	Environment	118	5
13	Environment	21	5	Environment	16	2
14	Health	118	5	Environment	16	1
15	Health	161	2	Environment	161	1
16	Environment	16	1	Health	21	2
17	Environment	21	2	Health	161	2
18	Environment	118	1	Health	118	2
19	Health	118	1	Environment	118	2
20	Environment	16	1	Health	16	2
21	Health	118	2	Health	161	5
22	Health	16	2	Health	21	5
23	Environment	161	1	Health	161	1
24	Health	21	2	Environment	16	5

Notes: The length of benefit was displayed to participants both in weeks and in its yearly equivalent in brackets for ease of comparison.

No further questions were presented, as the socio-demographic details of particpants were already held by Prolific Academic and were made available to us.

A.6 Prolific Academic Pre-screening Text

The following is the text presented to subjects when answering the Prolific Academic database profiling questions. This pre-screening occurs when subjects first sign up to the Prolific Academic database and is not linked to this particular experiment.

Age
Question asked: What is your date of birth?

Ethnicity
Question asked: What is your ethnicity?

Student Status
Question asked: Are you a student?

Employment Status
Question asked: What is your employment status?

Highest education level
Question asked: What is the highest level of education you have completed?

Marital status
Question asked: What is your relationship/marital status?

Current Country of Residence
Question asked: In what country do you currently reside?

Children
Question asked: Do you have any children?

Smoker
Question asked: Some researchers study people who do not smoke tobacco products, while others study people who do smoke. Do you regularly smoke tobacco products (cigarettes, cigars)?

Pain Question

Question asked: Throughout our lives, most of us have had pain from time to time (such as minor headaches, sprains and toothaches). Have you had pain other than these everyday kinds of pain?

Chronic Disease

Question asked: Have you been diagnosed with any chronic diseases such as diabetes, heart disease, stroke etc.?

Long-term health condition/disability

Question asked: Would you describe yourself as having a long-term health condition or a disability?

Sex

Question asked: What sex were you assigned at birth, such as on an original birth certificate?

Windfarms

Question asked: To what extent would you be in favour of or opposed to the building of a new wind farm near where you live? Please answer between 1 (I would strongly oppose the local wind farm) to 7 (I would strongly support the local wind farm)

A.7 Supplementary Tables to Chapter 4

The tables below display the results of the conditional logit regression on the three different model specifications outlined in Section 4.3. The first and second models follow the specifications presented in Viscusi et al. (2008). Following this paper we also present the implied discount rates for these two models. The goodness of fit comparison between the conditional and mixed logit are also displayed.

Table A.19: CONDITIONAL LOGIT REGRESSION RESULTS MODEL 1

VARIABLES	choice
Outcome	0.00804***
	(0.00179)
Magnitude	2.281***
	(0.130)
Delay	-0.394***
	(0.0271)
Domain	-0.343***
	(0.0856)
Delay#c.Outcome	-0.00356**
	(0.00142)
Delay#c.Outcome	-0.00230
	(0.00265)
Observations	12,000
Log pseudolikelihood	-3392.24
p-value	0.00

Notes: The results for the clogit regression are displayed. Where Outcome is a continuous variable used to motivate waiting for a delay, Magnitude is a dummy variable that takes on the value of 1 for the larger magnitude, Delay is the waiting period in years, Domain is a dummy variable that takes the value of 1 for the environment domain, The Delay#Outcome is an interacted variable that joins a continuous outcome variable to a categorical delay variable. Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table A.20: MODEL 1 DISCOUNT FACTOR AND DISCOUNT RATE

Delay	DF	DR
2	0.7464	34%
5	0.9349	7%

Notes: Column 2 displays the discount factor (DF) that results from the estimated coefficients. Column 3 displays the implied discount rate (DR) arising from the corresponding discount factor.

This model yields discount rates of 34% for a two year delay and 7% for a 5 year delay as can be seen in Table A.20 below.[1]

[1]Following Viscusi et al. (2008) in our model β_2 is the change in utility brought about by a unitary increase in the outcome. This can be interpreted as the instantaneous value. β_5 is the change in utility brought about by a unitary increase in the outcome given the outcome has been delayed by 1 year. The discount rate is the δ^t that equates the two: $\beta_1\delta^t = \beta_1 + \beta_5$ for a t year delay. We can obtain the discount factor (DF) by solving for δ. In addition we can then calculate the related discount rate (DR) using the equivalence $DF = \frac{1}{1+DR}$.

Table A.21: CONDITIONAL LOGIT REGRESSION RESULTS MODEL 2

VARIABLES	choice
Outcome	0.0136***
	(0.00342)
Magnitude	2.281***
	(0.1305)
Delay	-0.394***
	(0.0271)
Domain	-0.343***
	(0.0856)
Outcome#Delay	-0.00654***
	(0.00236)
Outcome#DelaySquared	0.000995***
	(0.000332)
Observations	12,000
Log pseudolikelihood	-3392.24
p-value	0.00

Notes: The results for the clogit regression are displayed. Where Outcome is a continuous variable used to motivate waiting for a delay, Magnitude is a dummy variable that takes on the value of 1 for the larger magnitude, Delay is the waiting period in years, Domain is a dummy variable that takes the value of 1 for the environment domain, The Delay#Outcome is an interacted variable that joins two continuous variables and the Outcome#DelaySquared is an interacted quadratic variable combining two continuous variables. Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table A.22: QUADRATIC MODEL DISCOUNT FACTOR AND DISCOUNT RATE

Delay	DF	DR
2 yr	0.5741	74%
5 yr	0.8418	19%

Notes: Column 2 displays the discount factor (DF) that results from the estimated coefficients. Column 3 displays the implied discount rate (DR) arising from the corresponding discount factor.

Table A.23: REGRESSION RESULTS FULLY INTERACTED MODEL

VARIABLES	choice
Outcome	0.00987***
	(0.00351)
Magnitude	2.977***
	(0.221)
Magnitude#Outcome	-0.00249
	(0.00413)
Delay	-0.505***
	(0.0495)
Outcome#Delay	-0.000167
	(0.00134)
Magnitude#Delay	0.225***
	(0.0660)
Magnitude#Outcome#Delay	-0.00154
	(0.00157)
Domain	1.557***
	(0.255)
Domain#Outcome	-0.0341***
	(0.00618)
Magnitude#Domain	-1.761***
	(0.352)
Magnitude#Domain#Outcome	0.0418***
	(0.00865)
Domain#Delay	0.447***
	(0.0934)
Domain#Outcome#Delay	-0.0108***
	(0.00226)
Magnitude#Domain#Delay	-0.639***
	(0.126)
Magnitude#Domain#Outcome#Delay	0.0139***
	(0.003)
Observations	12,000
Log pseudolikelihood	-3368.59
p-value	0.00

Notes: The results for the clogit regression are displayed. Robust standard errors in parentheses; ***

In order to evaluate the model fit we present Bayes information criteria (BIC) results for conditional logit compared to mixed logit model. It is clear from these results that the mixed logit provides an improved estimation of all three models as they result in lower BIC values.

Table A.24: MODEL FIT COMPARISON

	Conditional Logit	Mixed Logit
Model 1	6841.8	5133.0
Model 2	6846.2	5164.1
Model 3	6878.1	5211.5

Notes: The results for the Bayesian Information Criterion (BIC) for both model specifications and regression models are displayed.

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