Risk, Inequality and Time: How Can Public Attitudes Be Incorporated Better Into The Economics of Climate Change?

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Disclaimer

Except where otherwise stated and acknowledged I certify that this Dissertation is my sole and unaided work.

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Abstract

Much of the debate following the publication of the Stern Review of the Economics of Climate Change has focused on one single parameter in the economic model, labelled η. Currently, this parameter represents simultaneously a measure of aversion against risk as well as against inequality both within generations and across generations. This debate is important for two reasons. Firstly, cost estimates of climate change damages are highly sensitive to how risk, inequality and time are dealt with. The choice of optimal climate policy therefore depends crucially on the value of η. Secondly, the approach taken to risk, time and inequality involves important value judgements that should not be left to economists alone.

This dissertation makes two contributions to the debate. It tests the validity of using a single parameter to incorporate these three different concepts. This is done by surveying the attitudes of over 3000 people to risk, time, and income inequality. The results indicate that there is a clear need for a new model that is rich enough to treat the three different components as distinct. The paper then proceeds to develop such a model.

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Acronyms and Variables

Acronyms

BAU	Business As Ususal
BGE	Balanced Growth Equivalent
PAGE2002	Policy Analysis of the Greenhouse Effect 2002
IMF	International Monetary Fund
EU	Expected Utility
SWF	Social Welfare Function

Variables

c	Consumption
g	Growth rate of consumption
η	Elasticity of marginal utility of consumption
η_r	Coefficient of relative risk aversion
η_I	Coefficient of relative aversion against income inequality
η_{In}	Coefficient of relative aversion against income inequality on the national level
η_{Ig}	Coefficient of relative aversion against income inequality on the global level
η_t	Coefficient of relative aversion against inter-temporal inequality in income
δ	Utility discount rate / Rate of pure time preference
p	Probability
r	Market interest rate
s	Elasticity of inter-temporal substitution
U	Utility
y	Income

1 Introduction

There is by now a strong consensus among scientists that emissions of anthropogenic greenhouse gases are causing the global climate to change. The IPCC (2007a) has concluded that warming of the climate system is unequivocal and that most of it is very likely attributable to human influences. It is also becoming increasingly clear that the consequences could potentially be very severe, with the IPCC (2007b) warning that a warming world will place hundreds of millions of extra people at greater risk of food and water shortages and threaten the survival of thousands of species of plants and animals.

The next question that must be considered is whether anything should be done to control the emissions of greenhouse gases, and if so, how much? Among the many approaches to answering this question, an economic analysis comparing the costs and benefits of action on climate change stands out as a particularly rigorous method. Many people therefore took note when Sir Nicholas Stern (2006 hereandafter 'Stern') presented the most authoritative economic analysis of climate change to date in October last year. In contrast to most other economists that have studied climate change, Stern reached the conclusion that "The benefits of strong, early action on climate change outweigh the costs" (p. i).

As is evident from the debate following its publication, this report will not be the last word on the issue. Any economic study of climate change will be highly contestable because this problem presents a unique challenge to the economic discipline, pushing the framework to its limits. The nature of this challenge is dictated by the science of climate change (Dietz 2006). The physical characteristics of the climate system

demand that we develop systematic and legitimate techniques firstly for incorporating the high levels of uncertainty associated with future climate change, and secondly, for aggregating costs and benefits across space and time in a way that takes into account large differences in consumption levels.

These challenges presented by the science of climate change put emphasis on another source of inputs into the economic analysis, namely ethics. This is what this paper concerns itself with. In particular, it focuses on the answers to three questions: 1) How much risk should be taken with the future economy? 2) How should impacts on poor people be weighed relative to impacts on their rich contemporaries? 3) How much weight should be given to rich generations relative to poorer ones?

It may seem surprising, but the standard economic framework actually gives the same answer to all three of these questions. In fact it lets one parameter determine the approach taken to these ethical considerations. This parameter, labelled by the Greek letter η (pronounced eta) will be thoroughly described in the literature review, as will the assumptions behind the use of one parameter to answer three questions. For now, it is sufficient to think of it as representing simultaneously a measure of 1) aversion to risk, 2) aversion to intra-temporal inequality and 3) aversion to inter-temporal inequality.

Much of the criticism on the Stern Review from other economists focused exactly on the parameter η. One reason is that it embodies important value judgements. Another reason is that estimates of the costs of climate change impacts are highly sensitive to the value used. Following this debate, Stern (2007a), Beckerman and Hepburn (2007)

and Dietz (2006) have all called for work into disentangling η into components that address risk, intra-temporal inequality and inter-temporal inequality in isolation.

This paper approaches this issue both on an empirical and theoretical level. Its aims are:

1) To investigate the validity of treating these three seemingly distinct issues as one by conducting a survey of the attitudes of citizens from around the world.
2) To develop a new theoretical model that disentangles the different concepts.

The survey was conducted on-line and was completed by over 3000 respondents. The motivation behind consulting the views of the public is that the approach taken to risk and inequality across space and time reflects important value judgements that should not be monopolised by economists, ethicists and other academics. Since we cannot rely on individual behaviour in markets to reveal these social values, the survey presents a unique opportunity to incorporate the attitudes of the general public.

In addition to looking separately at risk, intra-temporal inequality and inter-temporal inequality, the survey will also be used to investigate whether attitudes to intra-temporal inequality differ depending on whether one looks at inequality within a nation or on a global scale. Furthermore, the results will give an indication of whether the absolute value for η used by Stern and other economists can be said to reflect the attitudes of the wider public on the different issues. Lastly, it investigates what factors influence personal attitudes towards risk, inequality and time.

2 Literature Review

2.1 Cost-benefit analysis applied to climate change

A cost-benefit analysis of climate policy is a monumental task which puts economics as well as science and ethics to severe tests. Perhaps the most controversial question is how to come up with one figure that summarises costs that are highly uncertain, occur over long time periods and affect people at a wide range of consumption levels. This is the question this paper concerns itself with.

2.2 The three dimensions of aggregation

The costs of climate change must be aggregated across three different dimensions. The first dimension is different possible states of the world. Scientists cannot predict exactly what the consequences will be if emissions continue unabated. There are uncertainties both in the physical and socioeconomic systems. Economists must therefore take into account many possible scenarios when calculating climate change damage costs. In other words, they must incorporate risk and uncertainty. The second dimension is temporal. How are costs arising 200 years from now to be compared with costs today? The third dimension is spatial. How do you compare impacts on people at very different income levels? These aggregations are determined by the three concepts this paper focuses on: aversion to risk, aversion to intra-temporal inequality and aversion to inter-temporal inequality.

2.3 The current framework

As all other economists that have analysed climate change, Stern uses a model based on the Expected Utility (EU) theory developed by von-Neumann and Morgenstern (1944). This is the standard economic model for analysing choice under uncertainty. The central idea of EU theory is that people are not concerned ultimately with money but with the well-being derived from consumption. This well-being is referred to as utility. As Kahnemann and Tversky (1979 and 1992) have forcefully argued, EU theory fails to explain how people actually behave in many situations involving risk. However, it is still seen as a useful normative theory for how it is rational to act (Frank 2003) and therefore seen as appropriate to use in the economics of climate change.

EU theory employs a single utility function that simultaneously determines attitudes towards risk, intra-temporal inequality and inter-temporal inequality. As Quiggin (2006) points out, when the standard technical assumption of constant relative risk aversion is added, (almost) everything is determined by η. Technically, this parameter is defined as (the negative of) the elasticity of marginal utility of consumption[1]. It is related to the intuitive idea that the increase in utility resulting from one additional pound is smaller the richer you are. In other words, a pound is worth less when you are rich than when you are poor. This is known as diminishing marginal utility of consumption. What η describes is how quickly marginal utility diminishes. Precisely, it measures the percentage decrease in marginal utility resulting from a 1% increase in consumption. This parameter determines the curvature of the utility function describing welfare as a function of consumption: $U=f(c)$.

[1] It is sometimes defined in terms of income or wealth instead of consumption. Under plausible models of saving, the three are interchangeable (Stern 1977).

The assumption of diminishing marginal utility has implication for all three types of aggregation, producing three further assumptions:

1) A pound is worth more in a bad state of the world than in a good state. This implies that a rational person may be willing to buy insurance whose expected monetary value is negative, because the expected *utility* from buying may still be positive.
2) A pound is worth more to a poor person today than a rich person today. This implies that transferring money from a rich person to a poor person increases the sum of their utility.
3) Assuming that future generations will be richer than the current, a pound is worth more today than in the future. This implies that future consumption should be discounted even if the welfare of the current and future generations are given the same weight.

All of these effects are stronger the larger η is. Hence a high η means high aversion against risk, large benefits from redistribution and high preference for current consumption.

2.3.1 The standard model

This model defines social welfare as the sum of expected discounted utility. It begins by specifying individual utility at time *t* (U_{ti}) as a function of individual consumption at time *t* (c_{ti}) in the following way:

(2.1) $U_{ti} = \frac{c_{ti}^{1-\eta}}{1-\eta}$

Consumption is defined in the broadest sense, encompassing everything a person may derive pleasure from. Hence it includes non-market goods such as an unspoilt environment and good health, for which willingness-to-pay is estimated using various techniques.

The above function has the property of Constant Relative Risk Aversion. To understand what this means, we first define the relative risk premium as the maximum share of one's consumption that one is willing to pay to escape a risk of losing a given share of ones consumption. The relative risk premium is proportional to what is called the Coefficient of Relative Risk Aversion. For the above function, this coefficient is constant and equal to η. Therefore the function is said to be isoelastic. With this specification, risk preferences are completely determined by η.

The next step is to aggregate individual utility (U_i) into a measure of social welfare. This is done through a Social Welfare Function (SWF). This function should be thought of as reflection of the attitudes of the social planner. Which SWF to use is an ethical question. The standard in economics is the Utilitarian SWF, which defines social welfare as the sum of the utilities of individuals. For excellent defences of this value judgement see Broome (1992) and Layard (2005). Social welfare at time t can then be expressed as:

$$(2.2)\quad W_t = \sum_{i=1}^{N} U_{ti}$$

Adding the ethically sound assumption that every person derives the same level of utility from a given level of consumption, social preferences for income distribution are now determined completely by η, which in this case also represents the coefficient of relative aversion against inequality, defined analogously to the coefficient of relative risk aversion.

In an inter-temporal setting, welfare in each period is aggregated according to the Discounted Utility model developed by Samuelson in 1937:

$$(2.3)\quad V = \sum_{t=1}^{T} W_t (1+\delta)^{-t}$$

Hence, total welfare is the sum of welfare in each period, discounted at the rate δ, which is known as the utility discount rate or rate of pure time preference. This specification means that η is also the coefficient of relative aversion against inter-temporal inequality. The Discounted Utility model was developed to describe individual behaviour over a lifetime. When it is applied across generations, future generations are treated as if they were later stages in the lives of the current generation.

The value for *V* should be found for every possible outcome *i* of a climate change policy. Stern's model was re-run 1000 times for each emissions scenario allowing 31 key parameters to vary stochastically between each run. The EU theory then dictates

that we find the expected level of *V*, by taking the weighted average where weights are the subjective probabilities of each outcome:

$$(2.4)\quad E(V) = \sum_{i=1}^{N} p_i V_i$$

E(V) expresses the expected discounted utility arising from a policy choice. Since utils are not a very meaningful metric, *E(V)* can be converted into its Balanced Growth Equivalent (BGE), which is the level of consumption today that, if it grew at an arbitrarily chosen constant rate, would generate utility *E(V).* This is how Stern derives his estimate that the total cost of BAU climate change equals an average reduction in global per-capita consumption by 5-20% now and forever.

2.3.2 Risk

The EU model gives more weight to the worst possible outcomes because of diminishing marginal utility. Hence it incorporates the precautionary principle in a limited sense. The importance of taking uncertainty adequately into account is illustrated by Dietz (2006). The same model Stern used was re-run with all the stochastic parameters set at their mode value, representing best-guess estimates. This is the approach taken by earlier economic studies of climate change. Compared with the EU approach, this underestimates the cost of BAU climate change by around two-thirds.

2.3.3 Time

To illustrate how the model incorporates time, it is instructive to derive the optimal consumption discount rate (ρ). This can be used to evaluate policies that amount to a small perturbation along a given path; hence it can be used to find the social cost of emitting one additional tonne of carbon (SCC).

As Ramsey (1928) showed, the isoelastic utility function gives rise to the following optimal discount rate:

$$(2.5) \quad \rho = \eta \times g + \delta$$

where g is the expected growth rate of consumption. Future utility is discounted at the rate δ, which is another important ethical input into the model. Stern sets it revolutionary low at 0.1, chosen to reflect the possibility that future generations may not be around. Hence, the main rationale for discounting is that we expect future generations to be richer, and therefore derive less utility from marginal consumption. Estimates of the SCC are extremely sensitive to the discount rate, as illustrated by Nordhaus (2006).

2.3.4 Inequality

If the level of utility was calculated for each individual, aversion to intra-temporal substitution would have been automatically taken into account. However, this is not practical. Stern made a big simplification by assuming that all individuals in each time period have the same level of consumption. Because of decreasing marginal utility,

this produces an incorrect measure of total utility. And because climate change is expected to hit poor people the hardest (IPCC 2007b and Stern), this approach will underestimate the welfare cost of climate change. Other models (Nordhaus and Boyer 2000, Tol 2002) take into account inequality between different world regions by finding regional per-capita utility and multiplying it by regional population, and then summing across regions to find global utility. Based on the results of Nordhaus and Boyer, Stern assumes that accounting for regional inequality would increase the cost of climate change by around one quarter, which is how the 20% figure is arrived at. This still underestimates the cost of climate change because income inequalities within each region are not taken into account. Anthoff *et al* (2006) find that the estimated SCC can be more than twice as high if national rather than regional impacts are aggregated. Stern also points out that climate change affects the poor people within each nation more than the rich, and this is not taken into account by any existing model. Hence an important task for modellers is to increase the resolution of the distribution of consumption and climate change impacts.

2.4 What values for η are used?

To get a sense of what different values for η imply, consider an example of intra-temporal transfers between a rich person R with twice the consumption of a poor person P. It can be shown easily that giving £1 to P increases utility by the same amount as giving $£2^{\eta}$ to R.

Stern sets the value of η to unity. This is consistent with the HM Treasury (2003) guidelines. It is also in line with a number of empirical studies, but it is at the lower range of what most economists believe are reasonable estimates. One of the most

common criticisms against Stern is that this value is too low. Such a claim has been made by a number of distinguished economists, including Nordhaus (2006), Dasgupta (2006), Weitzman (2007) and Gollier (2006). The next section investigates what implications different values for η have for the estimated cost of climate change.

2.5 The relationship between η and estimated damage costs of climate change

In the current model it cannot be predicted *a priori* what effect changing the value of η has on the estimated costs of damages from climate change. This is because, as long as the three components of η are not disentangled, increasing the value of η will have opposing effects on the damage estimates. Higher aversion to inequality across time has the effect of lowering damage estimates, because it increases the discount rate as long as expected future growth rates are positive. Higher risk aversion, on the other hand, increases the damage estimates, as more weight is placed on the most severe outcomes. This is reinforced by higher aversion to intra-temporal inequality.

To determine the overall effect, it is necessary to perform a sensitivity analysis, which means to re-run the model for different values of the parameter. This was done as a postscript which was nevertheless included in the Cambridge University Press publication of the Stern Review. Since the model does not formally incorporate intra-temporal distribution, only the effects of higher risk aversion and higher aversion to inter-temporal inequality are at work.

Table 2.1: Estimates of the discounted total cost of BAU climate change, in terms of BGE losses, for different elasticities of marginal utility of consumption.

Elasticity of marginal utility of consumption	*Mean BGE losses (% loss in current consumption per capita).*	
	Baseline climate	*High climate*
1.0	11.1	14.7
1.25	8.7	12.1
1.5	6.5	10.2
2.0	3.6	7.4
2.5	2.1	8.1
3.0	1.3	13.2

Sources: Dietz (2007) and Dietz (2006).

The two different climate scenarios make different assumptions about how sensitive temperatures are to concentrations of greenhouse gases. For the baseline-climate scenario, the higher discount rate dominates. Indeed, the estimated loss falls drastically as η increases. Raising η from 1 to 2 reduces the value of climate change losses by over two-thirds, while a value of 3 reduces it by almost 90%.

In the high-climate scenario, risk aversion has a stronger effect, because the model now produces more high-impact scenarios (Dietz 2006). For relatively high values of η, higher risk aversion actually begins to dominate higher aversion to inter-temporal inequality, and damage estimates begin to rise again.

Two important points emerge from this analysis. Firstly, the economic analysis of climate change is highly sensitive to the value of η. This serves to justify why it has been such a central point in the debate following the publication of the Stern Review.

Finding the optimal climate policy depends crucially on this parameter. Secondly, disentangling the three components could have very significant implications. Whether this would increase or decrease damage cost estimates is not clear *a priori*.

2.6 Should η be disentangled?

In response to the criticism outlined above, it has been suggested that disentangling the treatment of risk, intra-temporal and inter-temporal inequality may reduce the domain for disagreement. This section reviews some arguments both why the three concepts are similar and why they are different. Subscripts are henceforth added to η, to distinguish the different components, see list of acronyms.

2.6.1 Similarity arguments

A link between risk and intra-temporal inequality was first presented by Harsanyi (1955). He tries to identify people's 'moral preferences', which are distinguished from ordinary preferences by being impartial and impersonal. He argues that these preferences would be revealed if people made choices behind a hypothetical 'veil of ignorance', implying that they are ignorant of their own future position and characteristics in society. Unaware of which position they would have, Harsanyi claims that rational individuals would choose the income distribution that maximizes their EU. Hence, moral preferences for income distribution are determined by individual risk aversion.

The first objection to this argument is that it is not clear that every rational individual would maximize EU in this situation. Rawls (1971) argues that people behind a veil

of ignorance would instead choose the distribution that maximizes the welfare of the worst-off person. The second objection is that, as Barry (1989) has argued, it is not clear that individual preferences over gambles have anything to do with what social situations are better than others.

Parfit (1984) presents an argument that distribution across people should be regarded similarly as distribution between different stages of one person's lifetime. However, Broome (1991) presents several disanalogies between these two types of aggregation that Parfit fails to deal with adequately.

The most in-debt discussion of aggregation across all three dimensions is provided by Broome (1991). He shows that if all three dimensions are 'separable', consistency *may* require that aggregation is done in the same manner in each dimension. This is suggested by mathematical theorems. So what does separability imply? Each dimension contains a set of locations. For risk, the locations are states of the world. For time, they are time-periods, and for intra-temporal distribution they are people. A dimension is separable if the value of what happens in one location is independent of what happens in another location. Broome is willing to argue that the separability-condition is satisfied for risk, but finds it problematic for time, and implausible for intra-temporal distribution of income. Hence, Broome stops short of advocating that the three different aspects should be treated the same.

2.6.2 Difference arguments

It is clear that if social welfare is not defined as the simple sum of individual utilities, then inequality aversion is not determined solely by η. Other SWFs give more weight

to the utility of the worst-off than the utility of the best-off. In that case, aversion to consumption inequality is the product of the elasticity of marginal utility of consumption and the elasticity of marginal social welfare with respect to individual utility (Fankhauser *et al* 1997). Hence if utility is not strictly additive either over time or across people, the link between the three different concepts breaks down. Rawls (1971) argues for a SWF that maximizes the utility of the worst-off person (maxi-min). This implies that $\eta_I=\infty$.

The fast-developing field of happiness economics, which incorporates direct measures of people's well-being into economics, provides several insights into why η should be disentangled. Central to this literature is the observation that people in the West have not become happier over the last 50 years despite a drastic increase in consumption (Layard 2005). This suggests that inter-temporal inequality is less important. Looking at cross-country data, Layard finds that there is a clear positive relationship between consumption and happiness up to a per-capita income level of $20,000, and recent research (Economist 2007a) suggests that this relationship may hold for even higher levels. Hence, intra-temporal inequality seems to matter more, at least up to a certain income level.

One of the explanations for why happiness has failed to increase is that people care about their relative levels of consumption. Johansson-Stenmann *et al* (2002) specify this in a model by letting individual utility depend negatively on the mean level of income in society. In this model, inequality aversion is greater than risk aversion. The relative income theory also suggests that inequality within a country may be more

serious than inequality between countries, which is suggested also by empirical findings (Di Tella and MacCoulloch 2006).

Very similar implications follow if people are willing to pay for living in a more equal society *per se.* This willingness to pay could arise because they think that a more equal income distribution may lead to less crime and a more compassionate society. The results of Carlsson *et al* (2005) suggest that this is the case for most people, and the authors suggest that it means that risk aversion and inequality aversion are no longer the same. It also suggests that inequality within a nation is more important than inequality across nations, and that intra-temporal inequality is more serious than inter-temporal inequality.

2.7 Different methods for measuring attitudes towards risk and inequality

Empirical estimates of attitudes towards risk and inequality can be divided into two types: revealed-preference studies and stated-preference studies. The former looks at actual behaviour while the latter looks at responses to survey questions.

Several studies try to estimate aversion to risk and inter-temporal inequality on a personal level by looking at behaviour in markets. Gollier (2006) advocates a value for η_r of 2-4 based on behaviour in insurance markets. Based on changes in consumption in the period 1970-1986 in the UK, Blundell *et al* (1994) suggest that η_t varies from 0.35 to 1.05 for different income levels. In contrast, Hall (1988) presents very high estimates for η_t based on similar studies in the USA.

For estimating η_I directly, markets are not of much help. However, several studies (see Stern 1977, Cowell and Gardiner 1999 and Evans 2005) look at the degree of inequality aversion implicit in the tax and benefit systems. Estimates are in the range 1-2.

There are several difficulties with relying on these revealed-preference studies for informing climate change policy. Firstly, the data is often of poor quality. Secondly, market imperfections may distort choices and individuals often behave in an inconsistent manner, especially when it comes to saving. Thirdly, it is far from clear that self-interested individual behaviour in markets provides a good guide to how society should act collectively.

Similarly, the tax system is an outcome of a complex political process, rather than an optimization problem (Stern 2007).

However, rejecting the 'revealed ethics' of the market and political systems does not imply that we have to exclude the public from expressing their views on these important ethical questions. This paper takes the alternative approach of using a survey consisting of thought experiments to estimate people's values for the different components of η. Stated-preference surveys have sought to estimate different components of η before, but risk, intra-temporal inequality and inter-temporal inequality have never been incorporated into the same survey. Existing work is also less applicable to climate policy because of shorter time horizons and a focus on individual preferences rather than social values.

3 Survey Methodology

3.1 Introduction

The data for this dissertation was collected using an online questionnaire, the *Climate Ethics Survey*. The design and distribution of the survey was undertaken in collaboration with Jennifer Helgeson. Six versions of the questionnaire were created in order to accommodate different currencies and different levels of purchasing power. Individual versions were targeted at the UK, the US, Canada, Australia and Mexico; while respondents from other countries were offered a general version, with figures in US dollars. In total, 3645 people responded to the survey. Examiners are invited to complete the survey at: http://hakon.red-redemption.com//index.php?sid=25. The questions used to inform this paper are reproduced in Appendix I.

3.2 The internet as a medium for academic surveys

For some years, the internet has played a major role in marketing research (Charness *et al* 2003), and it is also increasingly used as a medium for experiments in economics and psychology. In these fields, the alternative is typically so-called lab experiments, in which research is conducted on a relatively small sample in a controlled environment. This was also the main alternative for this study, and the following section therefore draws on the literature comparing online and lab experiments for research in economics and psychology.

It is increasingly recognised that the online medium has a number of advantages. In general, online research is less costly than the alternatives. As Scmidt and Jacobsen (1999) point out, this facilitates higher participation rates and increasing power of

statistical tests. We would not have been able to collect anywhere near as many respondents had we not used the internet.

Online research also allows for great sample heterogeneity. In lab experiments the subjects are typically all students, a group which makes up only 3% of the general population (Reips 2000). Increased heterogeneity of respondents may contribute to the 'generalisability' of observed results. An important advantage of the internet for this *Climate Ethics Survey* is the ability to collect an international sample. We received responses from residents of 92 countries.

On the other hand, the researcher has less control over the population base when the sample is recruited through websites and e-mail (Charness *et al* 2003). This can lead to increased issues of self-selection. Self-selection is likely to have played a large role in our sample, as those who have a strong opinion on climate change would be more inclined to take the survey. And since we encouraged people to pass the invitation email on, we have no control over who actually received the link and subsequently, are unable to calculate a response rate.

Online research also leads to a loss of control over the environment in which the respondent answers the survey. Anderhub *et al* (2001) list a number of potential problems this can cause for economic experiments. The issue that most affects the *Climate Ethics Survey* is that it may be harder to ensure that subjects participate in a serious manner. To address this, care was taken to give the survey an academic look, with a professional design (e.g. use of the Oxford University logo).

An important question for researchers is whether subjects behave less attentively in internet experiments compared to lab experiments. This was a key issue for the *Climate Ethics Survey* because many of the questions are cognitively demanding. Anderhub *et al*. have investigated the issue by repeating an online experiment in a laboratory using the same software. The experiment consisted of an economic game where figuring out the optimal strategy was quite complex. Overall, the authors conclude that the differences of results were not as large as might be expected, and that the internet is a sound environment for experimental economics. Another study by Bosch-Domènech *et al* (2002) also obtained results online and in a lab that were very similar. All in all, Reips (2000) concludes that the advantages of online research outweigh the disadvantages.

3.3 Survey Distribution

3.3.1 E-mail lists

The survey was distributed through a number of different e-mail lists, to which access was gained by contacting the administrators. These lists are given in Appendix II. An email presented the survey briefly, and invited recipients to pass it on.

3.3.2 Facebook

Facebook is an international social networking website originally restricted to university students but opened up to the general public in September 2006. As of July 2007 it had 31 million members (Economist 2007b). The Climate Ethics Survey was advertised through this website. A short invitation to take the survey was seen by 99,823 users over the course of two days. Out of these, 8,185 clicked on the survey

link, but the proportion of total respondents who came through this route is not known.

3.3.3 Incentive to take part

No financial incentive to take the survey was offered. According to Cowell and Schokkaert (2001) it is not clear that rewards to participants are necessary in the context of social judgements. Nevertheless, in future work it would be desirable to offer some form of financial incentive in order to reduce the self-selection bias.

3.4 Survey Design

3.4.1 Software

The survey software PHPSurveyor gave a professional look to the survey, and was flexible enough to allow for designing the questions in a way that is more user-friendly than would have been possible with a paper survey. Technical assistance was provided by Hannah Rowlands of Red Redemption Ltd.

3.4.2 Design of the survey as a whole

The questionnaire was designed to inform both this paper and the dissertation of Jennifer Helgeson, and hence contained some questions that will not be reported here.

The survey was divided into three main parts. The first section questioned respondents about their general attitudes towards risk and their concern about climate change. In addition, there was one question that sought to gauge respondents' political views. The aim was to find out how respondents ranked on a likert-scale from liberal to conservative on fiscal issues. The question therefore asked about respondents'

views on the role of the government in redistributing income from rich to poor. It is based on use and research by Jowell *et al* (1997).

After the relatively easy questions of Section 1, respondents were then presented with the more challenging questions of Sections 2-6, aimed at eliciting their level of aversion against risk, inter-temporal inequality and inequality between people. The design of these questions is described in detail below.

Graphs were used to help illustrate the questions on intra-temporal and inter-temporal inequality. This is in line with recent research on stated preference surveys, which suggests that visual illustrations may increase the 'evaluability' of numeric questions (Bateman *et al* 2006).

Demographic questions were put at the end of the survey, following the advice of Thomas (2004). These were asked in order to investigate what personal attributes influence attitudes towards risk and inequality and to gauge the extent of bias in the sample.

The number of questions was kept relatively low, totalling 32. In addition, all questions were made optional. It is generally not desirable to have mandatory questions in a survey (Thomas 2004; and Atkinson, pers. comm.); this applies particularly to some of the questions in this survey due to their complexity. Forcing respondents to choose an option when they cannot decide would result in many random responses and degradation of the final data set.

3.4.3 Pilot testing

A draft version of the questionnaire was sent out to classmates in Oxford. Twelve students provided detailed feedback. The survey was also tested by Giles Atkinson and Simon Dietz of the London School of Economics, who are both respected experts in the field of stated preference surveys. Atkinson also distributed the pilot to a small test sample, in order to provide feedback from people without a background in environmental studies.

A major revision was undertaken in response to this feedback. Many testers found the survey cognitively very demanding. To address this issue, more explanations and examples were added, the language was simplified and the illustrations were made easier to interpret. To facilitate well-considered responses, it is important to keep the questions as simple to understand as possible.

3.4.4 Design of questions on η

These questions were designed in close collaboration with Dr. Simon Dietz.

To ensure that respondents answered the questions we were intending to ask, it was necessary to specify a number of assumptions in the instructions. These can be found in Appendix I. Only the most central ones will be referred to in this section.

3.4.4.1 Risk aversion

Climate change presents risks that have two distinguishing characteristics: they are potentially very large and could affect the entire global economy. In contrast, existing

studies in economics and psychology tend to focus on small risks to one or a few individuals. The Climate Ethics Survey attempts to present results that are more relevant to climate policy by investigating attitudes towards large risks to the national economy. The structure of the questions borrows heavily from Barsky *et al* (1997) but the framing is modified to measure aversion against societal rather than individual risk.

In the first question, respondents are asked whether they would be willing to have their government adopt a policy that gives equal chance of doubling the national average income and cutting it by 33%. Those who answered 'Yes' ('No') are presented with a second question which is identical, except that the amount by which income is cut is now 50% (15%). Similarly, those answering 'Yes' ('No') to the second question will be given a third question in which the policy is more (less) risky. This triple-bounded dichotomous choice format makes it possible to divide respondents into eight categories by asking them only three questions each. Using an electronic format, this structure was much simpler to present than it would have been if a paper survey was used.

In the standard economic framework, the responses to these questions can be used to derive a measure of aversion against risk to society. An expected utility-maximiser whose income changes proportionally to national average income will accept a policy which gives a 50% chance that income doubles and a 50% chance that it will fall by a fraction of θ, if and only if

$$(3.1) \quad \left[\frac{1}{2}U(2y)+\frac{1}{2}U(1-\theta)y\right] \geq U(y)$$

where *y* denotes national average income. Assuming an isoelastic utility function, this becomes

$$(3.2)\quad \left[\frac{\frac{1}{2}(2y)^{1-\eta_r}}{1-\eta_r}+\frac{\frac{1}{2}((1-\theta)y)^{1-\eta_r}}{1-\eta_r}\right]\geq\frac{y^{1-\eta_r}}{1-\eta_r}$$

for $\eta_r \neq 1$, which simplifies to

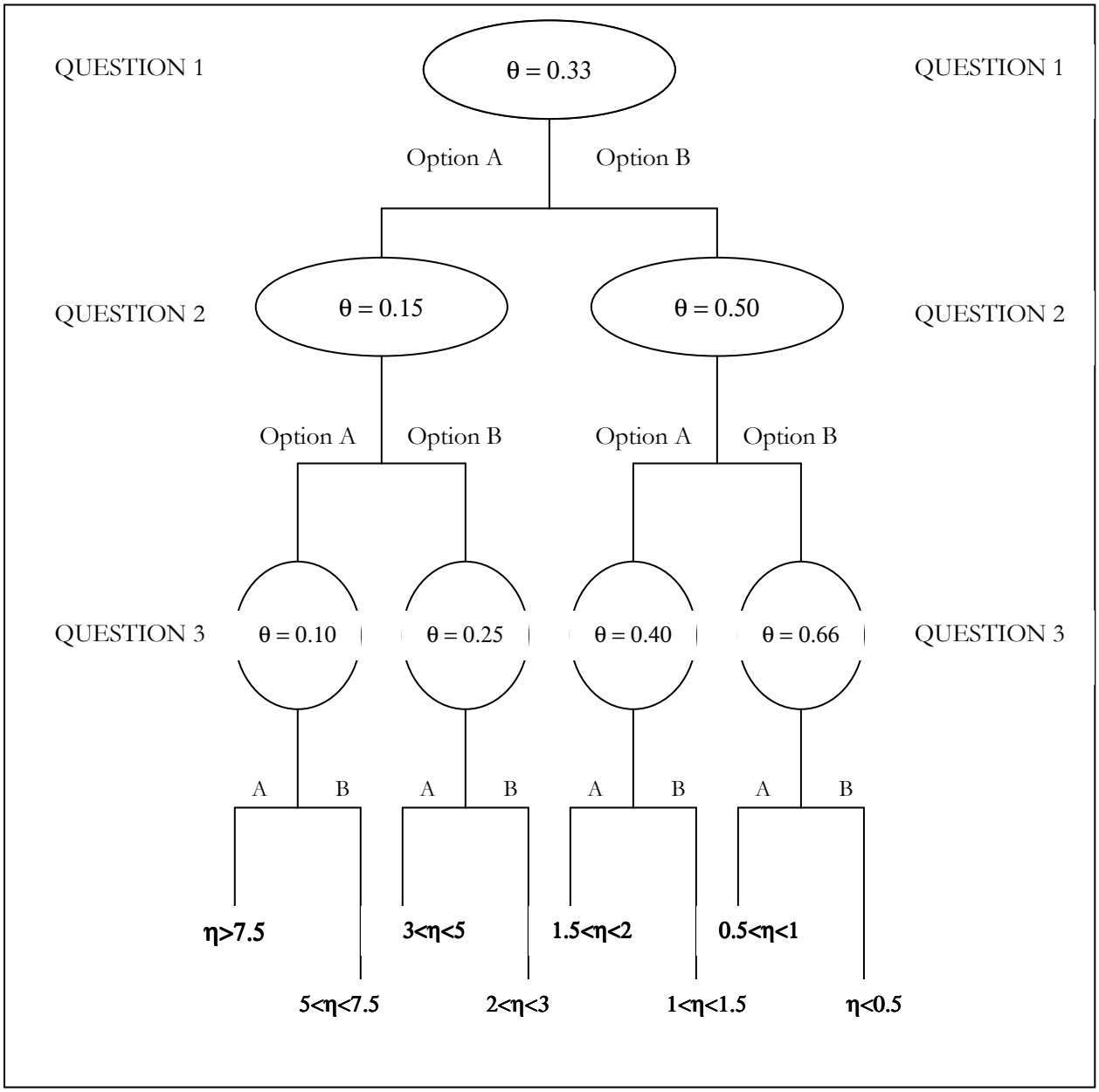
$$(3.3)\quad \left[\frac{\frac{1}{2}(2)^{1-\eta_r}}{1-\eta_r}+\frac{\frac{1}{2}(1-\theta)^{1-\eta_r}}{1-\eta_r}\right]\geq\frac{1}{1-\eta_r}$$

For $\eta_r=1$, the equation is

$$(3.4)\quad \left[\frac{1}{2}\ln(2)+\frac{1}{2}\ln(1-\theta)\right]\geq 0$$

where η_r is the coefficient of relative risk aversion. These equations can be used to find intervals for η_r corresponding to each of the eight combinations of answers. Diagram 3.1 illustrates the structure of the questions in this section. It gives the θ values in each question, and shows what questions respondents will be asked based on their previous answer. Furthermore, it lists intervals for η_r into which respondents are categorised.

Diagram 3.1: Structure of questions on risk



3.4.4.2 National Income distribution

To investigate people's aversion to income inequality within a country, respondents are presented with a pair of hypothetical income distributions and asked to choose the one they found preferable. The options were described in terms of maximum (y_{max}), average and minimum income (y_{min}). Option A had the highest total income, while Option B had a more equal distribution. Each respondent were asked three such questions. Option A stayed the same in each, but the income levels in Option B were

different for each of the three questions. This made it possible to see how much total income the respondent was willing to trade off for a more equal distribution. The questions in this section are based on survey questions used by Carlsson *et al* (2005) and Johansson-Stenmann *et al* (2002).

The same triple-bounded format as for risk is used again. A respondent that chose Option A (B) in the first question would be given a second question where the income levels in Option B were increased (reduced) relative to Option B in the first question.

In the standard economic model, responses to these questions can be used to derive estimates of the elasticity of marginal utility of consumption. In doing so, a number of assumptions must be made, three of which are particularly strong. The first assumption is that individual utility functions are of the isoelastic form. The second is that the social welfare function used by the respondent is of the additive, or utilitarian, form. Thirdly, it must be assumed that utility depends only on personal consumption. If these assumptions are relaxed, aversion to income inequality is no longer simply equal to the consumption elasticity of marginal utility. Rather, it is a function of several different parameters. This means that η_I as used here is a catch-all parameter. Ideally, one would disentangle it into different parameters, but this is beyond the scope of this paper, hence the use of a single parameter to describe attitudes towards income distribution. In any case it will be assumed that relative inequality aversion is constant for all levels of income.

Respondents were told that people were distributed uniformly between the two income extremes, since this distribution is particularly easy to interpret. With this distribution the social welfare arising from each income distribution is given by:

$$(3.5)\quad W = \int_{y_{\min}}^{y_{\max}} \left(\frac{y^{1-\eta_I}}{1-\eta_I} \right) \left(\frac{1}{y_{\max} - y_{\min}} \right) = \left(\frac{1}{(1-\eta_I)(2-\eta_I)} \right) \left(\frac{y_{\max}^{2-\eta_I} - y_{\min}^{2-\eta_I}}{y_{\max} - y_{\min}} \right)$$

where η_I refers to relative aversion intra-temporal income inequality. For the special case of $\eta_I=1$ we have:

$$(3.6)\quad W = \left(\frac{y_{\max} \ln y_{\max} - y_{\min} \ln y_{\min}}{y_{\max} - y_{\min}} \right) - 1$$

and for $\eta_I=2$ we have

$$(3.7)\quad W = \left(\frac{y_{\max} \ln y_{\max} - y_{\min} \ln y_{\min}}{y_{\max} - y_{\min}} \right) - 1$$

If a respondent is indifferent between distributions A and B, we have *W(A)=W(B)* and hence from (3.5) we have:

$$(3.8)\quad \left(\frac{y_{A\max}^{2-\eta_I} - y_{A\min}^{2-\eta_I}}{y_{A\max} - y_{A\min}} \right) = \left(\frac{y_{B\max}^{2-\eta_I} - y_{B\min}^{2-\eta_I}}{y_{B\max} - y_{B\min}} \right)$$

For $\eta_I=1$ and $\eta I=2$, the same is done using (3.6) and (3.7).

Solving this equation for η_I gives the minimum inequality aversion for someone choosing Option B, or the maximum value for someone choosing Option A.

The respondents are told to assume that their own position in the income distribution would be approximately the same as in reality. If respondents were choosing from behind a 'veil of ignorance', choices would be influenced by risk aversion, as stressed by Rawls (1971), and Harsanyi (1955). To keep risk aversion and inequality aversion separate, uncertainty about the respondent's personal position needs to be eliminated.

In theory, the absolute figures for income in the different options should not matter, only the ratios of differences are important. This is because the isoelastic utility function has the property of constant relative aversion to risk as well as inter-temporal inequality and inequality between people. However, this property is not necessarily reflected in the actual preferences that people have. On the dimension of intra-temporal inequality, recent work by Atkinson and Brandolini (2006) calls the assumption of constant relative aversion into question. While this paper formally adopts the isoelastic utility function, the numbers quoted in the survey were chosen as to resemble real world figures. However, this had to be balanced against the aim of keeping figures round and understandable.

The ratio of four between the highest and the lowest income in option A is an exact reflection of the actual ratio between the real household disposable income of the 90^{th} percentile and the 10^{th} percentile in the UK (Office of National Statistics 2004a). The absolute numbers in the question are around 40 per cent higher than in reality, for two reasons. The first is to adjust for the assumption that health care, education etc. are

assumed to be privately funded. The second is that it made the numbers particularly round and easy to interpret.

The ratio between the highest and lowest incomes in the different B options had to be lower than in option A, but could otherwise be chosen quite freely. It was kept constant at 1.5. With this set, all the income figures followed from solving the following set of simultaneous equations for the desired values of η:

$$For\ \eta_r \neq 1, \eta_r \neq 2: \begin{cases} \left(\frac{4000^{2-\eta_I} - 1000^{2-\eta_I}}{4000 - 1000} \right) = \left(\frac{y_{B\max}^{2-\eta_{Ir}} - y_{B\min}^{2-\eta_I}}{y_{B\max} - y_{B\min}} \right) \\ y_{B\max} = 1.5 \times y_{B\min} \end{cases}$$

$$For\ \eta_r = 1: \begin{cases} \left(\frac{4000 \ln 4000 - 1000 \ln 1000}{4000 - 1000} \right) = \left(\frac{y_{B\max} \ln y_{B\max} - y_{B\min} \ln y_{B\min}}{y_{B\max} - y_{B\min}} \right) \\ y_{B\max} = 1.5 \times y_{B\min} \end{cases}$$

$$For\ \eta_r = 2: \begin{cases} \left(\frac{\ln 4000 - \ln 1000}{4000 - 1000} \right) = \left(\frac{\ln y_{B\max} - \ln y_{B\min}}{y_{B\max} - y_{B\min}} \right) \\ y_{B\max} = 1.5 \times y_{B\min} \end{cases}$$

For consistency, the interval boundaries for η from the risk questions were used also for income inequality.

For the versions of the survey in different currencies, the UK numbers were converted using purchasing power parity indices. These exchange rates are meant to equalize the purchasing power of different currencies in their home countries for a given basket of

goods. The rates used are from IMF (2007), but they served only as rough guidelines, since the figures needed to be kept round.

3.4.4.3 Global inequality

The format of this section is essentially the same as for national income. The chief difference is that the income levels are much lower and the spread much wider, to reflect the distribution in the real world.

Figures for maximum and minimum income are based on the 90th percentile and the 10^{th} percentile of the world income distribution in 2000, as reported by Dikhanov (2005). Numbers in Dikhanov's paper are reported in 1999 US dollars adjusted for purchasing power. For the purpose of this study, his numbers were converted into 2007 US dollars using inflation data from Sahr (2007). For the versions of the survey using different currencies, these dollar figures were then converted using market exchange rates.

3.4.4.4 Time

The questions in this section were inspired by the survey by Barsky *et al* (1997), who asked respondents to choose between different options for allocating consumption before and after retirement. According to the EU framework, the choice of how to allocate consumption over time will depend on three parameters. Firstly, it is affected by the aversion to inequality over time, denoted η_{ti} for person *i*. A person with a positive η_t will be willing to give up some amount of total consumption in order to have it spread more evenly over time. The higher is $\eta_{t,}$ the larger is this amount. Secondly, the choice depends on the respondent's individual rate of pure time

preference, δ. A positive δ means that the respondent prefers good things sooner rather than later, while a negative value means the opposite.

The last factor that affects the choice of consumption profile is the market interest rate (r). According to Barsky *et al* (1997), surveys in the existing literature do not distinguish properly between the individual's utility discount rate and the market discount rate. An example of this is seen in Cameron and Gerde's (2007) *Climate Policy Survey*. They seek to elicit individual discount rates, but responses will presumably be influenced by r, and this is not controlled for. One way to separate the two parameters is to ask for the preferred consumption path at more than one r, which is the approach we take.

Each question presents respondents with alternative consumption paths with different slopes. In each question, the present discounted value of each option is the same for a given interest rate. This interest rate is first set at zero, then in subsequent questions it is changed to 1.39% and -1.39%. By observing how the preferred consumption profile changes as r changes, one can isolate δ from r. Furthermore, this question design also makes it possible to separate η_t from δ.

Barsky *et al* investigated people's personal preferences for consumption paths by presenting options described in terms of personal spending levels in two periods, before and after retirement. Since this paper concerns itself with the consumption level of the economy as a whole and the relevant time frame for climate change economics is much longer than for retirement decisions, the question had to be reworded. Respondents were given the following information:

Some of the policies adopted by governments affect how the standard of living will change in the future. Many of these policies can be thought of in a way similar to your own decisions on how much to spend and how much to save.

They are then asked to choose between different government plans for spending and saving, each with different implications for the living standards in two different periods; now-2107 and 2107-2207. The measure of the living standard used is national average income. In theory, consumption is a better proxy, but the term income is easier for respondents to comprehend (Barsky *et al* 1997).

The first question contains only three options, and serves as a warm-up for respondents to familiarize themselves with the format. They are then presented with three further questions, each with five choice options.

To interpret the answers to these questions, we observe that Ramsey's formula for the optimum discount rate (2.5) can be rearrange to find the optimum growth rate of consumption for a given market interest rate:

$$(3.9) \quad g = s(r - \delta)$$

where $s=1/\eta_t$, in other words: the inverse of relative aversion to inter-temporal inequality. This parameter is referred to as the elasticity of inter-temporal substitution. It measures the strength of the willingness to inter-temporally substitute in consumption.

Equation (3.9) contains two known parameters, the percentage growth in consumption per year (g) and the market interest rate (r), and two unknown parameters, s_i and δ_i. From each of the questions, we observe a respondent's preferred g at a given r. Comparing choices in two questions makes it possible to solve for s_i and δ_i. However, since each question offers only five choices of g, it is likely that the respondent's most preferred g lies somewhere in between two choices. Their preferences can therefore only be estimated within a range. The third question makes it possible to narrow this range.

4 Results and Discussion

4.1 Sample size

In total, the survey received 3645 responses. The breakdown between the different versions of the survey is given in Table 4.1. In total 505 responses were considered anomalous due to reasons that will be described in section 4.4.1. These were discarded altogether, leaving 3140 responses in total. Since all the questions were optional, the total number of respondents varies slightly from question to question.

Table 4.1: Number of responses to each version of the survey

	Australia	Canada	Mexico	UK	USA	World	Total
Number of Respondents	190	1157	56	1036	435	771	3645

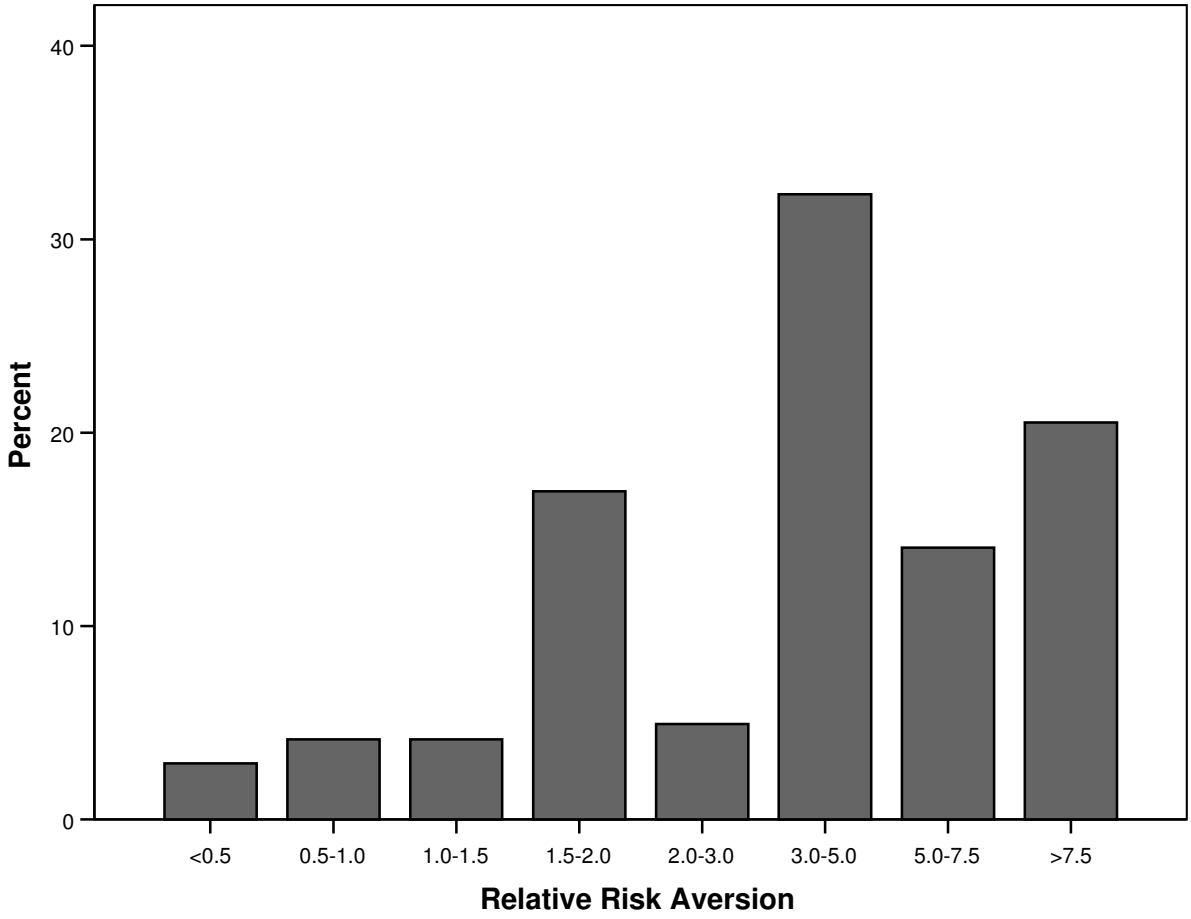
4.2 Risk aversion

The results for the question on aversion against risks to the national economy are summarised in Table 4.2 in Appendix III and illustrated in Diagram 4.1 below. The median estimated η_r is in the interval 3.0-5.0, and this is also the modal group. People in this group rejected a policy that gives an equal chance of doubling national income and of reducing it by one quarter, while accepting a policy where the reduction amounts to 15%.

To find the mean value for the sample, it is necessary to make some assumption about how η_r is distributed across individuals. Following Barsky *et al* (1997), it is assumed

that the inverse of η_r has a lognormal distribution. Based on this assumption, Maximum Likelihood Estimation produces a mean η_r of 3.0. and a median of 4.0.

Diagram 4.1: Distribution of responses to Risk question



These results indicate a very high level of risk aversion relative to what is employed in most economic analyses, but they are comparable to results of surveys that have estimated risk aversion to personal risk. Carlsson *et al*'s (2003) estimate is slightly lower than ours, with a median ηr between 2 and 3. On the other hand, Barsky *et al* (1997) obtain a higher estimate for the mean, with a value of 4.0.

4.3 Inequality aversion

Diagrams 4.2 and 4.3 present the results from the questions that sought to elicitate attitudes towards income inequality on a national and global scale. More details are

given in Tables 4.3 and 4.4 in Appendix III. The median respondent is found in the interval 3-5 for national inequality and in the interval 2-3 for global inequality. In both cases the mode is the upper extreme category for which η_I>7.5. Because of the large number of responses in both of the extreme categories, it is not possible to fit a distribution, hence the mean cannot be calculated.

Diagram 4.2: Distribution of responses to National Inequality question

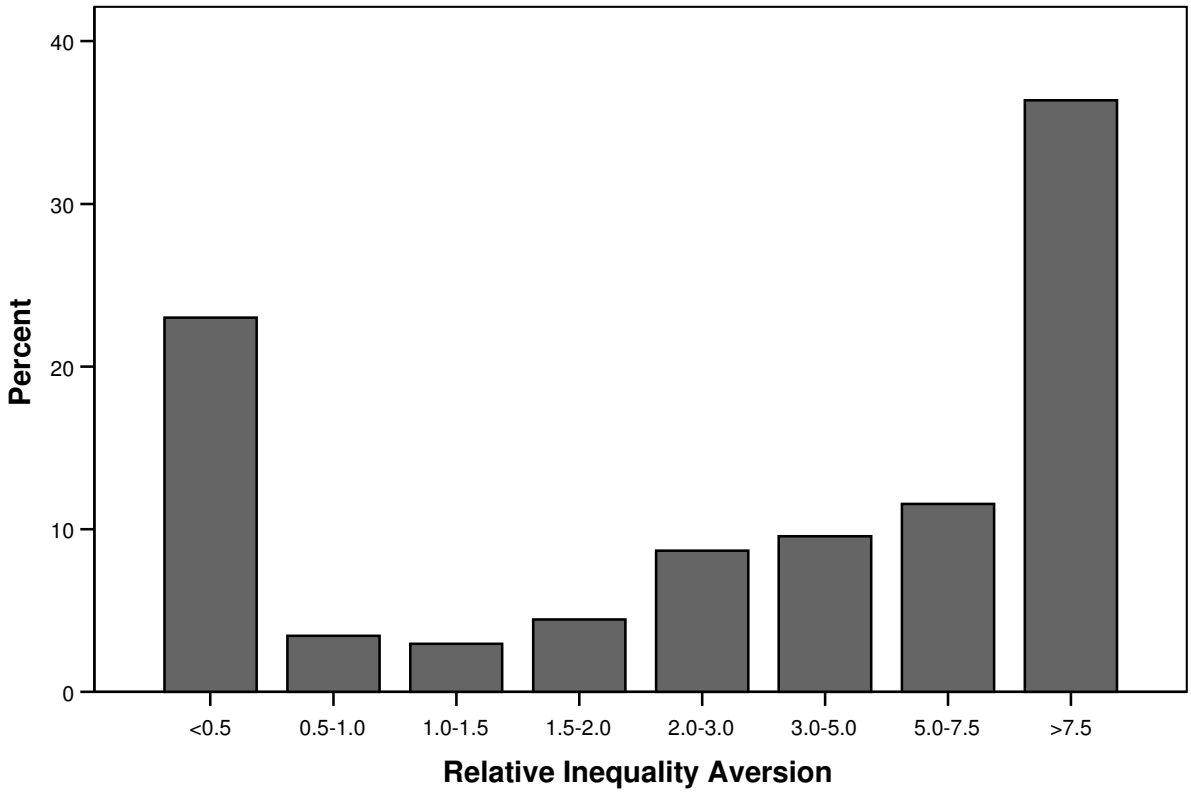
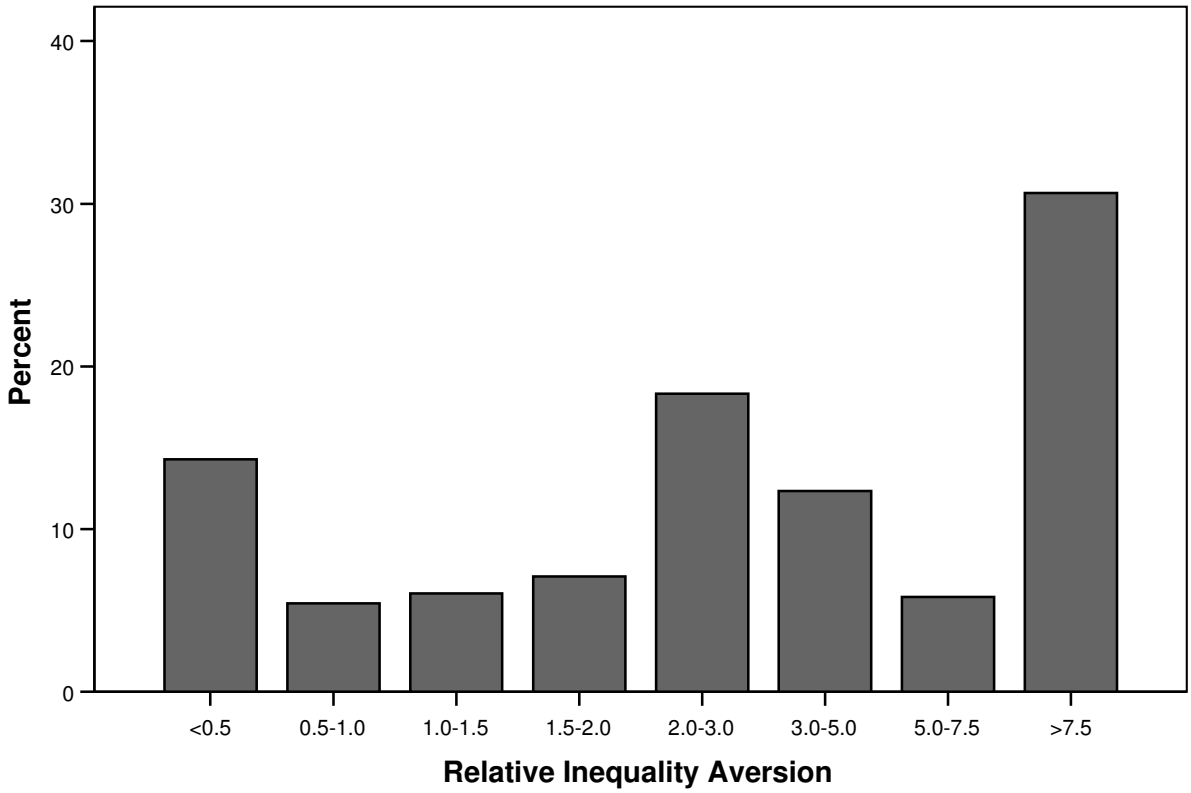


Diagram 4.3: Distribution of responses to Global Inequality question



Again, the estimates are strikingly high. If person R is twice as rich as person P, $\eta_I=3$ implies that one extra pound is worth $2^3=8$ times more to person P than to person R. For $\eta=4.5$, this ratio becomes $2^{4.5}=23$. A value for η_I above 7.5 implies a ratio in excess of $2^{7.5}=181$. Hence it seems that a large proportion of the sample follows Rawls' 'maxi-min' strategy.

This time the estimates are considerably higher than what other surveys have found. In Carlsson *et al*'s study, the median group for η_{In} is 1-2, while Amiel *et al* (1999) suggests a median as low as 0.10-0.22. Both these studies used samples consisting entirely of students, but this cannot explain the difference, as the median value for students in our sample is the same as for the sample as a whole. Instead, the

differences suggest that the estimates of η_I are sensitive to the framing of the question. In the latter study, respondents were asked to consider a hypothetical transfer from a rich to a poor person and state how much money could be lost in the process before the redistribution ceases to be desirable. However, this framing is inappropriate for informing how impacts of climate change should be aggregated because, as Buczsar and Knetsch (1997) have demonstrated, if the original distribution is seen to be somehow deserved, many people are opposed to such transfers even when there is zero loss.

A difference between Carlsson *et al*'s and our study is that they seek to investigate respondents' self-interested preferences while we focus on their social attitudes. It is unsurprising that the latter give higher values for inequality aversion, and Carlsson *et al* incorporate their results as an element that should be added to the individual utility function while keeping η unchanged.

The higher median η_I for national inequality than global inequality is consistent with the theories discussed in section 2.6.2 that relative income is important for peoples' welfare and that a more equal society accommodates desirable attributes such as lower crime and more social cohesion. Alternatively, it may arise because people exhibit agent-relative ethics, caring less about people the more spatially and culturally separated they are from one self. Thirdly, the differences could arise because of non-constant η_I, since the income levels were different in the two questions, but the sign of the difference in the medians does not seem to conform to Atkinson and Brandolini's (2006) arguments for a non-constant η_I. Lastly, the differences could arise because of a learning effect among respondents. This will be discussed below.

4.4 Time

4.4.1 Inconsistent responses

Unlike the previous sections, the questions on time allowed for responses that were inconsistent with utility maximisation. As can be seen in Appendix I, the first two questions were identical, except that the second contained two additional options. Out of the total of 3645 respondents, 141 (4%) answered these questions in an inconsistent manner. In addition, a further 416 (10%) reacted perversely to changes in the market interest rate (r), displaying a negative aversion to inter-temporal inequality, η_t. This implies that they would be willing to give up some total consumption to have it spread *less* evenly over time, which is unlikely to represent their true preferences. All of these respondents were dropped entirely from the dataset, because these inconsistencies indicate a lack of understanding and/or attention that is likely to have the rest of their responses as well. The rate of anomalous responses is lower than in Barsky *et al*'s experiment, where 29% displayed the same inconsistencies.

In addition, a further 322 responses were uninformative, despite being perfectly rational. These were people choosing always the most upward sloping or most downward sloping path regardless of r. No information about these respondents' values for η_t and δ can be derived. Hence they were treated as missing values for this section, but these respondents were still included in the analysis of the rest of the questions.

4.4.2 Aversion against inter-temporal inequality

Because of the large number of combinations of answers possible, the respondents cannot be grouped into a few non-overlapping groups. For each valid response, we calculated the range of values for the elasticity of inter-temporal substitution (*s*) consistent with the choices made. For 116 respondents, it was only possible to find the lower boundary of this range, because they switched from one extreme choice to the other as *r* changed.

Most respondents displayed very low tolerance for inter-temporal substitution. The mean lower bound is 0.06 and the median zero. These correspond to the very high values for η_t of 16.7 and infinity. Two-thirds of responses were actually consistent with s=0. The median upper bound is .2, which is equivalent to η_t=5. The only responses that were consistent with an upper bound larger than unity (corresponding to η_t lower than unity) were the 116 for which the upper bound could not be calculated.

These low values arise because respondents changed their preferred consumption path very little in response to changes in r. The most common response (24%) was to choose always the flat path. The second most common response (20%) was to always prefer the moderately upward sloping path.

As a point estimate for each respondent, the midpoint between the upper and the lower boundary was calculated. The median value for this is .11, corresponding to a value for η_t as high as 8.8.

A low responsiveness to changes in *r* was also found by Barsky *et al*'s (1997) survey of aversion against inter-temporal inequality in private consumption. In their study, over 70% of respondents chose always a flat path or a moderately upward sloping path.

Both the results of this survey and Barsky *et al*'s survey are consistent with a revealed preference study by Hall (1988). His extensive evidence on the responsiveness of consumption growth to changes in the real interest rate in the post-World War II U.S leads him to conclude that *s* is probably less than .2 and may even be zero. On the other hand they contrast with the estimates of Blundell *et al* (1994) who find very low values of η_t.

4.4.3 Utility discount rate

While not the main focus of this paper, the question on time also provides information about δ, which can be found using equation (3.12). The results indicate that on average respondents have a negative δ. This contrasts with the critics arguing that Stern's value of 0.1 is too low.

These results are consistent with other stated-preference studies (Barsky *et al* 1997; Loewenstein and Prelec 1993) but contrast revealed-preference studies, which often find large positive values for δ (see e.g. Hausman 1979 and Lawrence 1991). They also run counter to the standard economic assumption that people are impatient, preferring good things sooner rather than later.

4.5 Possible explanations for the large proportion of extreme responses

The high proportion of responses falling into extreme categories is quite surprising. For all the different questions, there is a large number of people displaying a value for η above 7.5, which is higher than the range most economists consider reasonable. This is particularly true for the questions on inter-temporal and intra-temporal inequality. For the latter issue, there is also a high score for the bottom category, for which the upper bound is η=0.5, also outside the range normally considered reasonable. The results for η_{In} are the most polarised, with 59% of respondents in one of the two extreme categories.

Before concluding that that these estimates reflect the actual attitudes of the public, it is necessary to investigate two alternative explanations.

The first is that there is an overrepresentation of people in the sample with extreme attitudes, which could arise as a result of self-selection bias. This will be explored in section 4.8. In short, there is no strong evidence for this.

The other possibility is that the answers do not reflect respondents' true underlying attitudes, but are influenced by the format of elicitation. One possibility is that many respondents found the questions exceedingly complex and therefore reverted to lexicographic strategies. This means ranking the options with reference to only one of the attributes instead of making a trade-off. In this case, such strategies would amount to only considering either the minimum, maximum or average/expected income. This would imply always choosing the same option, which would put the respondent in one

of the extreme categories for risk and inequality and the highest category for aversion to inter-temporal inequality.

This could account for some of the differences in the number of extreme responses to the different questions. Judging from the feedback on pilot questions, the one on risk presented the fewest difficulties, therefore respondents may have relied less on lexicographic strategies than for the other questions. There may also be an element of learning effect, as the number of extreme responses fall from national inequality to global inequality and then to risk, which corresponds to the order in which the questions were asked. As respondents became more trained in answering the questions, they may have relied less and less on lexicographic strategies.

On the other hand, it is not implausible that people's true attitudes towards income inequality are quite polarised. The maxi-min strategy advocated as the most ethical by Rawls (1971) implies $\eta=\infty$. Similarly, a strict egalitarianist may be of the view that the marginal social welfare of income to rich people is negative since higher income for the rich leads to increased inequality. Such individuals would advocate reducing the income of the rich even if this did not raise the income of the poorest. This would also imply $\eta=\infty$. Other people may see the distribution of income they observe in reality as fair, reflecting 'just deserts'. Since distribution A was chosen to reflect the actual distribution in the UK, these individuals may have chosen not to depart from this option. This would lead to an estimated η of less than 0.5. Furthermore, to the extent that the global income distribution is seen as less reflective of 'just deserts' than the national distribution, this could help explain the large difference in frequency for the bottom category between these two questions.

If it is true that a large proportion of the public actually do hold rather extreme attitudes to inequality, it could be considered problematic for using economic analysis to inform climate change policy. The high level of heterogeneity found in this survey would be difficult to accommodate in an economic framework even if η is split up into several different components.

The highest proportion of extremely high aversion is found for inter-temporal inequality. In hindsight it appears that the formatting of the question may be partly responsible for this. The reason is that the formula for estimating s ($1/\eta_t$) is quite sensitive to the time-frame of the question. To see this, equation (3.9) is rewritten as:

$$(4.1) \quad \frac{\Delta \log c}{n} = s_i (r - \delta_i)$$

where c refers to consumption in each period and n to the number of years in each period. The left-hand side of this equation describes the annual growth rate of consumption as before. Rearranging for s_i gives:

$$(4.2) \quad s_i = \frac{\Delta \log c}{n(r - \delta_i)}$$

which shows that there is an inverse relationship between s and n. If the length of each period is reduced by half, while everything else stays the same, the value for s corresponding to a given choice is doubled. The intuition behind is that as the time frame is shortened, a given difference in consumption between the two periods amounts to a larger annual growth rate. It is conceivable that respondents focus mostly on the difference in the consumption levels without giving much consideration

to the length of time between them, and that the results therefore overestimate respondent's aversion against inter-temporal inequality. To test for this, future work should present separate sub-samples with questions where the length of the period varies.

4.6 Comparison of sample distributions for the different dimensions of η.

The results reported above indicate that the central estimate for η_r and η_I are fairly similar, while for η_t it is markedly different. This section will look at the entire distribution of responses to each question in order to gain further insights into how the attitudes of the sample differed between the different aspects of η.

The discussion will be supported by using the Kolmogorov-Smirnov Goodness of Fit Test (K-S test) which tests whether two distributions are significantly different or not. While this test does not consider whether individual attitudes across the different dimension of η are linked, it gives an indication of whether the attitudes of the sample on aggregate are different or not. It is based on the maximum absolute difference between the two cumulative distribution functions (labelled D). If this is sufficiently large, the null-hypothesis that the two distributions are not different is rejected. This test considers both the shapes and the locations of the distributions.

Performing a K-S test on each possible pair of distributions gives the result that they are all significantly different at the 0.1% confidence level. This is rather unsurprising given the large sample size and the obvious differences in the results for the four

different questions. It lends some support to the argument against collapsing attitudes towards the different issues into one parameter, by showing that the values for the different components of η are distributed significantly differently in the sample. However, it does not indicate the relative – not to mention absolute – size of the different parameters.

The test is perhaps most useful for gauging which pairs of distributions are the most similar and which are the most different. All the D values are reported in Table 4.5 below. For example, it can be seen that the largest difference in cumulative percentage frequency between the distributions for national and global η_I is 11.4 percentage points.

Table 4.5: Results from K-S tests (D-values)

	National η_I	**Global η_I**	**η_r**	**η_t**
National η_I		11.4%	20.1%	34.6%
Global η_I	11.4%		18.1%	43.2%
η_r	20.1%	18.1%		47.9%
η_t	34.6%	43.2%	47.9%	

4.6.1 Risk, National Inequality and Global Inequality

While the medians for the two experiments on inequality aversion are more similar to the median for risk than they are to one another, comparing the entire distributions gives a different impression. As can be seen from the graphs in sections 4.2 and 4.3, the results from the questions on inequality are more polarised than those from the questions on risk, with more respondents in both of the extreme categories. The

argument is also supported by the K-S test results in Table 4.5. This can be taken to suggest that there are marked differences between attitudes towards risk and inequality while there is also a significant albeit smaller difference in how people evaluate inequality on a national versus a global scale.

4.6.2 Inter-temporal inequality compared to the rest

As seen in Table 4.5, the distribution of η_t is easily the one that is most dissimilar from the other ones.[2] This can be taken to indicate that inter-temporal inequality is evaluated quite differently from risk and intra-temporal inequality.

However, part of the difference may also be a result of the framing of the questions. As was explained in the Methodology, the formats for risk and intra-temporal inequality were very similar, while the question on time was structured differently, and, as discussed above, the number of people with very high values for η_t may have been inflated due to the long time frame of the question.

4.7 Correlations between the different dimensions of η

The above discussion compared the aggregate attitudes of the sample on the different components of η. Another interesting question is whether individual attitudes on the different dimensions are linked. For example, does high aversion against risk tend to go together with high aversion against inter-temporal inequality? This was

[2] In order to carry out the K-S test, responses to the time question were grouped into the same categories as those used for risk and intra-temporal inequality based on the midpoint of the estimated range for s. Those responses for which the upper bound on s could not be calculated were put into the category containing values of η from zero to 0.5. The same method was used for the regression analysis.

investigated by measuring the correlation between responses to the different questions.

Since most of the data is categorical, not continuous, the ordinary Pearson's r is not applicable. Instead, Kendall's tau-b is used, following the recommendation of De Vaus (2002). This test defines perfect correlation as strict monotonicity. Two variables are perfectly correlated if, (1) when one variable increases, then the other variable increases (or decreases for in the case of perfect negative correlation) and (2) each value of either variable corresponds to only one value of the other variable. For example, η_r and η_t is perfectly correlated if each respondent is found in the same category for both. Kendall's tau-b will then have a value of 1. A value of zero indicates that the two variables are statistically independent. If the assumption of the standard economic framework is justified, the correlation coefficients should be close to one.

All the correlation coefficients derived are given in Table 4.6. The correlation coefficient between η_I on the national and global level is .51. According to the guidelines of Cohen and Lea (2004) this can be considered a high level of correlation, yet it shows clearly that people do not view inequality within a nation and inequality on an international level as the same thing. Correlating either type of η_I with η_r yields coefficients of .13, which according to Cohen and Lea is low. The same is true for the relationship between η_I and η_t, for which the values are .12. The correlation between ηr and ηt is even weaker, with a value of .09.

The results indicate that the association between individual attitudes on the different aspects is rather low, supporting the proposition that they should be disentangled. On the other hand, all the correlations are significant, which means that the parameters are not statistically independent of one another.

4.8 Regressions and evaluation of sample bias

To investigate what personal characteristics are linked with values for η, a series of regressions are carried out, where the dependent variable is the η category and the explanatory variables are the responses given to questions on demographics and attitudes. This method estimates the impact on the dependent variable of a change in the explanatory variable holding all other variables equal.

4.8.1 Bias

While it is interesting to look at what influences responses for its own sake, the results of the regression are also useful for testing whether the results are affected by biases in the sample. Before doing so, the main biases of the sample must be identified. In this case they are likely to be age, education, income and interest in environmental issues.

The mean and median age are 30 and 27 years respectively. In comparison, the median age in the UK population is 39 years (Office of National Statistics 2005).

Perhaps the biggest bias is that the level of education is higher in the sample than in the general population. For example, only 5.5% respondents described their highest

level of education as "some high school or less". In comparison, 49% of the population in England and Wales can be fitted into this group.[3] Given the high level of education, income can also be expected to be high in the sample. In fact, median household income is in the group £40,000-£50,000 which is more than twice as high as the median for the UK population in 2002/03 of £16,800 (Office of National Statistics 2004a).

One indicator of bias in terms of interest in climate change is that 28% of respondents are members of environmental organisations or conservation groups. Attitudes on climate change were also gauged directly by asking them whether they agreed with the following statement: "The effects of climate change will pose serious risks to global society during the remainder of your lifetime". The distribution of responses to this question is displayed in Table 4.7 in Appendix III. Half the sample strongly agreed, while less than 10 per cent disagreed or strongly disagreed. This suggests that there may be an overrepresentation of highly concerned people, while the same cannot be said for people with strong views against action on climate change.

These biases will influence our results to the extent that there is an association between these characteristics and attitudes on risk, inequality and inter-temporal substitution. This can be investigated using the results of the regressions. If the biases are found to affect the results, and the sample proportions can be compared to the population proportions, it may be desirable to weight responses in order to eliminate them.

[3] Those in the groups 'No qualification' and 'Level 1'. See Appendix 99 for definitions of the groups.

4.8.2 The regression model

Again, the categorical nature of the data means that standard regression models cannot be used. Instead, the Ordered Probit model is employed. This model makes it possible to estimate what effect a change in an explanatory variable has on the probability of an individual being in each of the eight categories for η. This is called a marginal effect.

Since most of the demographic data is also categorical, one has to make use of so-called 'dummy variables', which are artificial variables with only two possible values, 0 and 1. For example, to estimate the effect of membership in environmental organisations, a dummy variable is created which is equal to 1 if the respondent is a member and 0 if she is not. The model can then estimate the effect of being a member of such an organisation has on the probability of being in the highest category for η, or on the probability of being in any one of the seven other categories.

When the demographic question has more than two options, the standard procedure is to choose one option as the reference category and then define dummy variables for each of the other options. It is good practice to choose the dominant or most normal option as the reference group (Dougherty 2002).

An important attribute of the Probit model is that the marginal effects are not constant. For example, when the probability of being in a specific category is very high, the marginal effect of a change in any of the explanatory variables is typically very low. This attribute implies that when calculating the marginal effect of one explanatory variable, all the other explanatory variables must be set at a fixed level.

Following the advice of Anderson and Newell (2003), all the dummy variables are set to 0. This means that what is being reported is the marginal effect a change in one variable has on a respondent whose other characteristics are described by the reference group in each question. Age is the only variable included that did not need to be treated as categorical. The marginal effects are calculated for the mean value of this variable, as recommended by Dougherty (2002).

The variables included in the regressions are listed in Table 4.7 below, which also gives the reference group for each variable.

Table 4.8: Variables included in regressions

Explanatory variable	**Reference group**
Region of citizenship	UK
Political view	Neutral
Climate change poses a serious threat to global society	Neither disagree nor agree
Gender	Male
Household Income	£40,000-£49,999
Highest level of education	Undergraduate degree
Membership in environmental group	Non-member

Marginal effects are calculated for the top and the bottom category for each dimension of η. An explanatory variable which has a positive marginal effect on the top category and a negative marginal effect on the bottom group can be assumed to have a positive effect on the dependent variable. Only variables that have significant

marginal effects on both extreme categories are reported. The confidence level used is 5%.

4.8.3 Regression results and discussion of biases.

4.8.3.1 Regional differences

In general, which region the respondent is from does not seem to strongly influence the responses, however there are some exceptions. Africans appear to have a lower value for η_I, while Scandinavians have a slightly higher value. Africans also appear to be less averse to inequality on a global scale, while Americans are more so. This may seem surprising given the difference in average income between these two regions, but remember that the regression holds every other variable constant, so it effectively compares people from different regions with the same income (adjusted for purchasing power).

4.8.3.2 Income

Income seems to be most closely linked to inequality aversion. There is some evidence of high income groups having lower values for both η_{Ig} and η_{In}, and of lower income groups having a higher value for η_{In}. This is unsurprising, as respondents were told to assume that their position in the hypothetical income distribution would be the same as in reality. If respondents were making the choices based on self-interest, a much stronger and more consistent relationship would be expected. However, Atkinson *et al* (2000) found that individual income did not strongly influence attitudes towards distribution.

Aversion against inter-temporal inequality also appears to be weakly associated with income, with respondents in the bottom income group displaying higher values.

These results suggest that a sample with a more representative income distribution would actually have produced larger estimates for these parameters. No measure was undertaken to correct for this bias, since it would make the results even more radical compared to the current practice. In this respect, the results can be regarded as conservative estimates.

4.8.3.3 Age

Another bias in the sample is the low average age. The regressions show that age has a small but significant positive effect on η_{In} and η_{t}. Again, in order to keep the estimates conservative, no attempt was made to correct for this bias.

4.8.3.4 Gender

Women have larger values for all the dimensions of η. Gender is the only variable that has a significant effect on all the different regressions. Higher risk aversion among women is consistent with the findings of Carlsson *et al* (2005), Barsky *et al* (1997), Hartog *et al* (2002) and Jianakoplos and Bernasek (1998). Carlsson *et al* (2005) also report the same result for inequality aversion. Fortunately, the number of men and the number of women in the sample were almost equal, accounting for 52% and 48% respectively, so the problem of gender bias is minimal.

4.8.3.5. Political views

The answers to the question on political views are tightly linked to the values for η_I both on the national and global level. This is perhaps unsurprising, since this question asked to what extent they agreed with the statement: "It is the responsibility of the government to reduce the differences in income between people with high incomes and those with low incomes." Nevertheless, it shows that inequality aversion is a highly politicised issue. The marginal effects are by some way the largest found in all the regressions. For example, those who strongly disagreed with this statement were 34% more likely than the reference group to be in the bottom category for η_{In} than the reference group. Frolich and Oppenheimer (1994) also found this strong relationship between political values and preferences for income distribution in their experiment.

To the extent that people with liberal views on the role of the government in redistribution were overrepresented in the sample, this may have lead to biased results. However, lacking information about the population characteristics on this issue, the magnitude of the sample bias cannot be established.

The fact that aversion to intra-temporal inequality is so closely connected to political views could explain why many people have either very high or very low values for it. Ideological views are not usually the most amenable to trading off different objectives. Again, if the people with strong political views were overrepresented in the sample, this could have also contributed to the polarisation.

The link to risk aversion is much weaker, but those most in favour of redistributive policies tend also to be more averse to risk. Political views do not seem to influence aversion against inter-temporal inequality.

4.8.3.6 Interest in the climate change

Membership in environmental organisations and conservation groups is associated with higher values for η_I. This indicates that the high proportion of members of such groups in our sample may have lead to higher estimates for inequality aversion than what is representative of the general population. However, the effect is not very large. The biggest implication is that members are 7% more likely to have a value for η_{Ig} in the top category than non-members. There is no significant effect of this characteristic on attitudes towards risk and inter-temporal substitution. Again, lack of information about the population characteristics precludes quantification of this bias.

Whether respondents viewed the impacts of climate change as a serious threat is not found to have a significant effect on responses to any of the questions. This indicates that the large proportion of the sample stating a high level of concern does not undermine the generalisability of the results. It also suggests that they were not answering the questions strategically to influence the outcome so that the implications for climate policy would concur with their own views.

4.8.3.7 Education

The only significant effect found when looking at education level is that those who described their highest level of education as 'some high school or less', had lower values for η_I, both on a national and global scale. As we have seen, this group is underrepresented in the sample. To investigate whether this affected the main results, the sample was weighted according to the guidelines of De Vaus (2002). The procedure for calculating the weights is given in Appendix IV. The weighted

frequency distributions obtained for intra-generational inequality and risk are given in Tables 4.9 and 4.10 in Appendix III.

The weighting has strongest effect on η_{In}, for which it changes the median category from 3-5 to 2-3. The mode actually changes all the way from the top to the bottom category. The median and mode category remain unchanged for η_{Ig}. However, the frequency in the top category falls by 10 percentage points, while the frequency of the bottom category increases by 6 percentage points. This means that the median group is now the same for η_{In} and η_{Ig}, while before it was the same for η_{In} and η_{r}.

The weighting has minimal effects on the results for risk and inter-temporal inequality, which was expected given that no significant relationship between the level of education and these variables was found in the regressions.

According to the K-S test, the distributions are more dissimilar when weights are used. As can be seen from Table 4.11 in Appendix IV, all the D-values are higher than before. The relative differences are not changed.

The weighting has the effect of reducing all the strength of all the correlations between the different aspects of η. Apart from the correlation between η_{Ig} and η_{In} which remains strong with a value of .48, all the other coefficients are now less than 0.1, and there is no longer a significant correlation between η for risk and inter-temporal inequality.

In sum, applying the weights further strengthens the case for disentangling the different components of η, both because the sample distributions are more dissimilar and because individual attitudes on the different aspects are less tightly linked. This indicates that a new model is needed that does not automatically conflate the three issues into one.

5 A new theoretical model for disentangling equality, risk and time

This new method is developed to enable a disentangling of aversion to risk, inter-temporal inequality and intra-temporal inequality. It builds on models by Kreps and Porteus (1978) and Selden (1978) which disentangle risk from inter-temporal substitution. The model does not differentiate between aversion to national inequality and global inequality. This would require information about the distribution of climate change impacts within each country that is currently not available. Also, the survey results show that the differences in attitudes towards the two types of intra-generational inequality are small compared to the differences between the three main components of η.

The model requires the same information as current models. And, like current models, it will give a more accurate estimate the more detailed information we have about the income distribution net of any climate change impacts. In the example, a resolution on the regional level is assumed. For each policy option, the model produces an estimate of total welfare over time that is adjusted for risk and inequality. Population growth is automatically taken into account.

The central idea is to use three different valuation functions, instead of the single utility function used in the standard framework.

5.1 Incorporating aversion against intra-temporal inequality.

It is assumed that we can estimate the consumption level in each region at each point in time for each of the possible outcomes of the policy. Define $\hat{c}$ as the vector of

average per capita consumption in each of the n region and the number of people in that region: (c_1, pop_1; c_2, pop_2;…; c_n, pop_n). To evaluate the welfare arising from this distribution we use a valuation function that describes social welfare as a function of individual consumption levels: $W(c_1, c_2,\ldots c_N)$ where N is the global population. The function W can take any form. For example, using an isoelastic utility function and a utilitarian social welfare function gives:

$$(5.1) \quad W = \sum_{i=1}^{N} \frac{c_i^{1-\eta_I}}{1-\eta_I}$$

The concavity of this function – which is determined by η_I – describes the degree of aversion against intra-temporal inequality alone. Now we define $d(\hat{c})$ as the level of global consumption that, if shared equally, would yield the same social welfare as the distribution represented by $\hat{c}$:

$$(5.2) \quad W(d) = W(\hat{c})$$

This equality-equivalent level of consumption is then found for each time period in each possible state of the world.

5.2 Incorporating risk aversion

It is assumed that we can assign subjective probabilities to each possible outcome. For each time period we now have a vector that we will call $\hat{d}$ of possible levels of d and the probability of that level occurring: $(d_1, p_1; d_2, p_2,\ldots d_m, p_m)$, where m is the number

of possible outcomes. A second function is used to describe attitudes to risk: $U_i=f(c_i)$, where U_i is the welfare realized if outcome i occurs. The constant elasticity function is:

$$(5.3)\quad U_i = \frac{c_i^{1-\eta_r}}{1-\eta_r}$$

The concavity of this function – which is determined by ηr – describes the degree of risk aversion alone. The goal of maximizing expected utility is maintained. As before,

$$(5.4)\quad EU = \sum_{i=1}^{m} p_i U_i$$

Now define the certainty equivalent g($\hat{d}$) of the uncertain prospect $\hat{d}$ as:

$$(5.5)\quad U(g) = EU(\hat{d})$$

This is the certain level of consumption that would yield the same expected welfare as the uncertain prospect $\hat{d}$. Now we have the certainty-and-equality-equivalent consumption level for each period.

5.3 Incorporating time preferences

A third function is used to aggregate consumption over different time periods. Assuming that the welfare function for each period is isoelastic and that discounted utility is additive over time, the function is:

$$(5.5) \quad V = \sum_{t=1}^{T} \left(\frac{g_t^{1-\eta_t}}{1-\eta_t} \right) (1-\delta)^t$$

V now represents a welfare measure of an uncertain and unequal future consumption path. One can then compare the value for *V* for different policies, like in the Stern Review. The metric that *V* is expressed in can be described as certainty-and-equality-equivalent-net-present-value-utils (Hepburn 2007, pers comm.).

Since, utils are not very practical metric for informing policy, it would make sense to convert them into a balanced growth equivalent, following the same procedure as Stern.

The standard model is a particular case of the new model, because if ηr=ηI=ηt we are back to the old model. The new model is hence a more generalized and richer version. It represents a way of incorporating different preferences for risk, intra-temporal distribution and inter-temporal distribution with minimal departure from the current framework.

6 Conclusions

6.1 Value of study

The approach taken to risk, equality and time is a crucial component of any economic analysis of climate change. As the literature review showed, estimates of damage costs are very sensitive to how this issues are dealt with. It has also been argued that the approach taken embodies important ethical judgments. These two points suggests that the economics of climate change should be sensitive to the views of the general public on the different concepts currently embodied in η. Yet, there has been very little public debate on the topic, probably due in large part to its technical nature.

This study has sought to address this lack of public involvement by surveying the attitudes of a sample of over 3000 people from around the world. By looking at all the dimensions within the same questionnaire, the study makes it possible to compare attitudes both on the aggregate and the individual level. Furthermore, the large and heterogeneous sample provides outstanding insights into how attitudes differ between different demographic groups.

The second significant contribution of this paper is a new economic model that disentangles risk, intra-temporal inequality and inter-temporal inequality. This model is simple and does not require more information than is currently available, yet it is richer than the old model because it allows for three dimensions of η to be treated as separate. This represents an important improvement for analyzing climate change and other policy-problems whose impacts are uncertain and widely dispersed through space and time.

6.2 Main findings of survey

The survey has found that attitudes differ considerably across the three main dimensions of η. The sample distributions are quite different, and individual values for the different aversion parameters are only weakly correlated. These findings are strengthened when the sample is weighted to correct for the bias in level of education. Hence, public attitudes provide a strong rationale for applying the new model which disentangles the three elements.

It was found that attitudes on intra-temporal inequality are highly polarized and closely linked to political views. This presents a bit of a headache for economists because it makes it very difficult to come up with one value that is acceptable to everyone. It also provides a strong rationale for public debate, and shows the danger of economists making strong ethical judgments in an in-transparent way.

The results also indicate that the different elements of η are influenced by different demographic and attitudinal characteristics. Only gender appears to influence all in a similar way.

6.3 Agenda for future research

The values for the different versions of η found in this survey are not intended to be used directly in the economic model. This is because the sample is not representative of the general population of any country, and because the source of the high proportion of extreme values must be investigated further. Neither can it be said with confidence which type of aversion is stronger. However, the results do indicate that $\eta=1$ is too low for all dimensions.

Hence, while this study has demonstrated that there are important differences in attitudes on the three different concepts embodied in η, further work is needed to establish the relative and absolute values for the different versions of η to be used in the new model. Ideally, both state-preference and revealed-preference methods should be employed.

For further survey work in the area, the following lessons should be drawn from this study:

- The sample should be representative of the population whose views are seen as relevant for informing the policy. This is particularly important with respect to the attributes found in this study to have a strong influence on attitudes.
- The high proportion of extreme answer may indicate that the questions did not succeed in elicitating the true attitudes of all respondents. This shows that for complex issues such as these, it is crucial to ensure that respondents are attentive and give well-considered responses. Focus groups would have an important advantage over the internet, because it allows for deliberation among the respondents and between respondents and an instructor. This is particularly desirable for a sample that is less educated than the sample used in this survey.
- The learning effect may have played a role in this survey. Future studies should randomize the order of questions to control for this effect.
- The results of stated-preference surveys are sensitive to the framing of the questions. It would be desirable to experiment with different framings to control for this influence. In particular, it should be investigated whether the

values for aversion to inter-temporal inequality are sensitive to the timeframe of the question.

Bibliography

Amiel, Y. and Cowell, F.A. (2000) Attitudes Towards Risk and Inequality: A Questionnaire experimental Approach. Discussion Paper DARP 56: Distributional Analysis Research Programme.

Amiel, Y., Creedy, J. and Hurn, S. (1999) Measuring Attitudes towards Inequality. Scandinavian Journal of Economics, 101(1):83-96.

Anderhub, V. (2001) Design and evaluation of an economic experiment via the internet. Journal of Economic Behaviour and Organization, 46: 227–247.

Anderson, S. and Newell, R.G. (2003) Simplified marginal effects in discrete choice models. Economics Letters, 81: 321-326.

Anthoff, D., Hepburn, C. and Tol, R. (2006): Equity weighting and the marginal damage costs of climate change, FNU Working Paper, November. Available at: http://www.economics.ox.ac.uk/members/cameron.hepburn/research.html [Accessed 30.08.07]

Atkinson, A. and Brandolini, A. (2006) Talk to Mirrlees 70 birthday seminar, July 2006 and forthcoming.

Atkinson, G. (2007) Personal Correspondence with Author dated 13 July 2007 (on file with author).

Atkinson, G., Machado, F. and Mourato, S. (2000): Balancing competing principles of environmental equity. Environment and Planning A, 32: 1791-1806.

Barry, B. (1989): Thories of Justice. London: Harvester-Wheatsheaf.

Barsky, R.B., Juster, F.T., Kimball, M.S., and Shapiro, M.D. (1997) Preference Parameters and Behavioral Heterogeneity: An Experimental Approach in the Health and Retirement Study. The Quarterly Journal of Economics, 112(2): 537-579.

Bateman, I.J., Jones, A.P, Jude, S. and Day, B.H. (2006) Reducing gains/loss asymmetry: A virtual reality choice experiment (VRCE) valuing land use change. CSERGE Working Paper EDM 06-16. Norwich, UK: University of East Anglia.

Beckerman, W. and Hepburn, C. (2007) Ethics of the Discount Rate in the Stern Review on the Economics of Climate Change. World Economics, 8(1): 187-210.

Blundell, R., Browning, M. and Meghir, C. (1994): Consumer demand and the life-cycle allocation of household expenditures. Review of Economic Studies, 61: 57–80.

Bosch-Domènech, A., Montalvo J.G., Nagel, R., and Satorra A. (2002) One, Two, [Three], Infinity: Newspaper and Lab Beauty-contest Experiments. The American Economic Review, 92(5): 1687-1701.

Bukszar, E., and Knetsch, J.L. (1997): Fragile Redistribution Choices Behind a Veil of Ignorance. Journal of Risk and Uncertainty, 14:63-74.

Broome, J. (1991) Weighing Goods: Equality, Uncertainty, and Time. Oxford: Basil Blackwell.

Cameron, T.A. and Gerdes, G.R. (2007) Discounting versus risk aversion: their effects on individual demands for climate change mitigation. Presented at the EAERE Conference, 2007.

Carlsson, F., Daruvala, D. and Johansson-Stenman, O. (2005) Are people inequality averse, or just risk-averse? Economica, 72: 375-396.

Charness, G., Haruvy, E., and Sonsino, D. (2003) Social Distance and Reciprocity: The Internet vs. the Laboratory. SSRN. Available at: http://ssrn.com/abstract=312141.

Cohen, B.H. and Lea, R.B. (2004) Essentials of Statistics for the Social and Behavioral Sciences. Chichester: John Wiley & Sons.

Cowell, F. A. and K. Gardiner (1999) Welfare Weights. Economics Research Paper 20, STICERD, London School of Economics and Political Science.

Cowell, F.A. and Schokkaert, E. (2001) Risk Perceptions and Distributional Judgments. European Economic Review, 45: 941-952.

Dasgupta, P. (2006) Comments on the Stern Review's Economics of Climate Change. Comments prepared for a seminar on The Stern Review organised by the Foundation for Science and Technology at the Royal Society, London, November 2006.

De Vaus, D.A. (1986) Surveys in social research. London: Unwin Hyman.

Dietz, S (2006) On Discounting Non-Marginal Policy Decisions and Cost-Benefit Analysis of Climate-Change Policy. Available at: SSRN:http://ssrn.com/abstract=957992. [Accessed 26.08.07]

Dietz, S. (2007) Discounting the benefits of climate-change policy: the Stern Review, its critics, and policy implications, presented at Envecon 2007: Applied Environmental Economics Conference, hosted by the UK Network of Environmental Economists (UKNEE), Royal Society, London, 23 March 2007

Dikhanov, Y. (2005) Trends in Global Income Distribution, 1970-2000, and Scenarios for 2015. Human Development Report Office Occasional Paper. New York, NY: UNDP.

Dougherty, C (2002), Introduction to econometrics. Oxford: Oxford University Press.

Economist (2007a), Where money seems to talk. Economist 384 (8537): 63-64

Economist (2007b), Book value. Economist 385 (8538): 72

Engelmann, D. and Stroebel, M. (2004) Inequality Aversion, Efficiency, and Maximin Preferences in Simple Distribution Experiments. The American Economic Review, 94 (4): 857-870.

Evans, D.J. (2005) The elasticity of marginal utility of consumption: estimates for 20 OECD countries in Fiscal Studies 25:2 pp 197-224.

Frank, R.H.. (2003) Microeconomics and Behaviour. New York, NY: McGraw-Hill.

Frolich, N. and Oppenheimer, J. (1994), Preferences for Income Distribution and Distributive Justice: A Window on the Problems of using Experimental Data in Economics and Ethics. Eastern Economic Journal, 20(2): 147-156.

Gollier, C. (2001) The Economics of Risk and Time. Cambridge: The MIT Press.

Gollier, C. (2006): 'Institue Outlook> Climate Change and Insurance: An Evaluation of The Stern Report On The Economics Of Climate Change'. Cambridge, MA: Barboun Institute.

Hall, R.E. (1988), Inter-temporal Substitution in Consumption, Journal of Political Economy, 96: 339-357.

Harsanyi, J.C. (1955), Cardinal Welfare, Individualistic Ethics, and Interpersonal Comparisons of Utility. The Journal of Political Economy, 63(4): 309-321.

Hartog, J., Ferrer-I-Carbonell, A. and Jonker, N. (2002), Linking measured risk aversion to observed characteristics. Kyklos (55): 3-26.

Hepburn, C. (2007), Personal Correspondence with Author dated 28 August 2007 (on file with author).

HM Treasury (2003), Appraisal and Evaluation in Central Government, The Green Book, London: HMSO.

International Monetary Fund (2007) World Economic Outlook Database, April 2007. Available at: http://www.imf.org/external/pubs/ft/weo/2007/01/data/weoselgr.aspx. [Accessed 15.07.07].

IPCC (2007a), Climate Change 2007 - The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the IPCC. Cambridge: Cambridge University Press.

IPCC (2007b): Climate Change 2007 - Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the IPCC. Cambridge: Cambridge University Press.

Jianakokplos, N.A. and Bernasek, A. (1998), Are women more risk averse? Economic Enquiry 36: 620-630.

Johansson-Stenman, O., Carlsson, F., and Daruvala, D. (2002) Measuring Future Grandparents' Preferences for Equality and Relative Standing. Economic Journal, 112: 362–383.

Jowell, R., Curtice, J., Park, A., Brook, L., Thomson, K., and Bryson, C. (eds.) (1997) British Social Attitudes (BSA), 14th Report, 1997/1998 Edition. Aldershot, UK: Ashgate Publishing Ltd.

Kahneman, D. and Tversky, A. (1979) Prospect Theory: An Analysis of Decision under Risk. Econometrica,
XVLII: 263-291.

Kahneman, D. and Tversky, A. (1992) Advances in prospect theory: Cumulative representation of uncertainty. Journal of Risk and Uncertainty, 5: 297-323.

Kahneman, D. and Knetsch, J (1992) Valuing public goods: the purchase of moral satisfaction. Journal of Environmental Economics and Management, 22: 57-70.

Kahneman, D. and Tversky, A. (1979) Prospect Theory: An Analysis of Decision under Risk. Econometrica, XVLII: 263-291.

Kreps, D.M. and E.L. Porteus (1978) Temporal Resolution of Uncertainty and Dynamic Choice.
Econometrica, 46: 185-200.

Layard, R (2005) Happiness: Lessons from a New Science. London: Penguin.

Loewenstein, G. and Prelec, D. (1993), Preferences for Sequences of Outcomes. Psychological Review 100 (1): 91-108.

Nordhaus, W. (2006) The Stern Review of the Economics of Climate Change. Available at:
http://nordhaus.econ.yale.edu/stern_050307.

Office of National Statistics (2004a): Focus on Social Inequality data – Summary report. Available at: http://www.statistics.gov.uk/statbase/Product.asp?vlnk=13488. [Accessed 05.07.07]

Office of National Statistics (2004b) KS13 Qualifications and students, Census 2001: Key Statistics for the rural and urban area classification 2004. Available at: http://www.statistics.gov.uk/statbase/Expodata/Spreadsheets/D6564.xls. [Accessed 17.08.07]

Office of National Statistics (2005) Age structure: Average age rose to 38.6 years in 2004. Available at:
http://www.statistics.gov.uk/CCI/nugget.asp?ID=1308&Pos=1&ColRank=2&Rank=224. [Accessed 17.08.07]

Parfit, D. (1984) Reasons and Persons. Oxford: Oxford University Press.

Quiggin, J. (2006) Stern and the Critics on Discounting. Available at: http://johnquiggin.com/wp-content/uploads/2006/12/sternreviewed06121.pdf. [Accessed 21.07.07]

Ramsey, F. P. (1928) A mathematical theory of saving. Economic Journal, 38: 543-559.

Rawls, J. (1971) A Theory of Justice. Oxford: Oxford University Press.

Reips, U. (2000) The Web Experiment Method: Advantages, Disadvantages, and Solutions. In Birnbaum, M. (ed) Psychological Experiments on the Internet, San Diego: Academic Press.

Sahr, R. (2007) Consumer Price Index (CPI) Conversion Factors 1800 to estimated 2016 to Convert to Dollars of 2006. Corvallis, OR: Oregon State University. Available at: http://oregonstate.edu/cla/polisci/faculty/sahr/cv2006.xls. [Accessed: 12.07.07]

Schmidt, C. and Jacobsen, H.A. (1999) Moving Experimental Economics to the Internet. Online proceedings of the 2nd Berlin Internet Economics Workshop.

Selden, L.R. (1978) A New Representation of Preference over 'Certain x Uncertain' Consumption Pairs: The 'Ordinal Certainty Equivalent' Hypothesis. Econometrica, 46(5): 1045-1060.

Stern, N. (1977) Welfare weights and the elasticity of the marginal valuation of income. In Artis, M. and Nobay, A.R. (eds) Studies in Modern Economic Analysis. Oxford: Basil Blackwell.

Stern, N. (2006) The Economics of Climate Change. London, HM Treasury.

Stern, N (2007) After the Stern Review: reflections and responses. Paper B: 'Value judgements, welfare weights and discounting: issues and evidence'. Available at: http://www.hm-treasury.gov.uk/media/C/8/Paper_B.pdf [Accessed 05.09.07]

Thomas, S. (2004) Using Web and Paper Questionnaires for Data-Based Decision Making: From Design to Interpretations of the Results. Thousand Oaks, CA: Corwin.

von Neumann, J. and O. Morgenstern (1944) Theory of Games and Economic Behaviour. Princeton, NJ: Princeton University Press.

Weitzman, M. L. (2007) The Stern Review of the economics of climate change, Journal of Economic Literature, forthcoming.

Appendix I: The Climate Ethics Survey (selected questions)

Please note that this survey is available on-line at:

http://hakon.red-redemption.com//index.php?sid=25

Survey Section 1: Attitudes/Opinions

Q.A.6:
Question 6.

What is your opinion of the following statement?

The effects of climate change will pose serious risks to YOU and YOUR FAMILY during the remainder of your lifetime.

Serious risks from climate change can include more extreme weather events, rising sea level, and negative impacts on human health, ecosystems and the economy.

Please choose **only one** of the following:

- ☐ Strongly Disagree
- ☐ Disagree
- ☐ Neither agree nor disagree
- ☐ Agree
- ☐ Strongly Agree

Q.A.7:
Question 7.

What is your opinion of the following statement?

The effects of climate change will pose serious risks to GLOBAL SOCIETY during the remainder of your lifetime.

Serious risks from climate change can include more extreme weather events, rising sea level, and negative impacts on human health, ecosystems and the economy.

Please choose **only one** of the following:

- ☐ Strongly Disagree
- ☐ Disagree
- ☐ Neither agree nor disagree
- ☐ Agree
- ☐ Strongly Agree

Survey Section 2: Income Distribution (National)

This section seeks to explore your attitudes toward the distribution of income within a country.

In reality, there is often a trade-off between achieving the highest total national income and creating an equal distribution between the rich and the poor. That is, policies aimed at distributing income from rich to poor often reduce the total 'size of the pie'.

The following questions require you to make such a trade-off. In each question, you will be asked to choose between two different distributions, labelled A and B. Option B gives a more equal distribution between rich and poor, but the total income is higher in Option A.

When answering these questions, assume that your position in the national income distribution is approximately the same as it is in reality.

Remember, there is no 'correct' answer to these questions, and we ask you to reflect on the choices carefully. If you change your mind along the way, you may of course change your earlier responses.

There are three questions in this section.

* **Q.I.N.1:**
Question 1.

	Min. Income	Average Income	Max. Income
Option A	$1,500	$3,750	$6,000
Option B	$2,630	$3,290	$3,950

Which national income distribution option would you prefer?

Assumptions:

There are no social programs to help the poorest people, and everyone has to pay for their own education, health care, etc.

The richest 10% and the poorest 10% of people lie outside the range stated in the question. Assume that these people are unaffected by your choice of distribution; your decision affects only the middle 80% of the population. Within this range, people are distributed evenly, so that there is the same number of people in the upper and the lower half of the distribution.

The options differ only in terms of their income distribution, and this distribution does not affect the future growth rate of the economy. The prices of goods are the same for both options; i.e. for $100 you can buy the same amount of goods in both options.

Please choose **only one** of the following:

- ☐ **Option A**
- ☐ **Option B**
- ☐ I choose not to answer

Q.I.N.2.1:
Question 2.
[Only respondents who answered '**Option A**' to question 'Q.I.N.1 ' see this question]

	Min. Income	Average Income	Max. Income
Option A	$1,500	$3,750	$6,000
Option B	$2,820	$3,525	$4,230

Which national income distribution option would you prefer?
Please choose **only one** of the following:

- ☐ **Option A**
- ☐ **Option B**
- ☐ I choose not to answer

Q.I.N.2.2:
Question 2.
[Only respondents who answered '**Option B**' to question 'Q.I.N.1 ' see this]

	Min. Income	Average Income	Max. Income
Option A	$1,500	$3,750	$6,000
Option B	$2,160	$2,700	$3,240

Which national income distribution option would you prefer?

Please choose **only one** of the following:

- ☐ **Option A**
- ☐ **Option B**
- ☐ I choose not to answer

Q.I.N.3.1:
Question 3.
[Only answer respondents who answered '**Option A**' to question 'Q.I.N.2.1 ' see this]

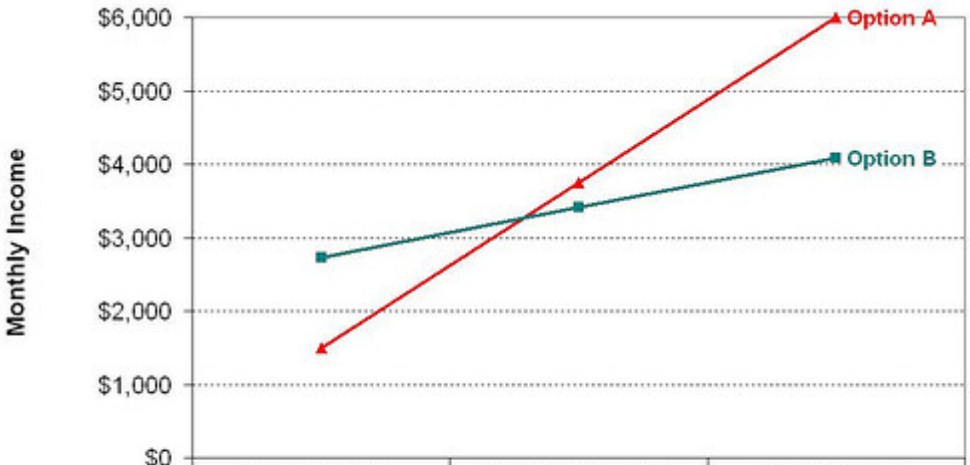
	Min. Income	Average Income	Max. Income
Option A	$1,500	$3,750	$6,000
Option B	$2,910	$3,640	$4,370

Which national income distribution option would you prefer?
Please choose **only one** of the following:

- ☐ **Option A**
- ☐ **Option B**
- ☐ I choose not to answer

Q.I.N.3.2:
Question 3.

[Only respondents who answered '**Option B**' to question 'Q.I.N.2.1 ' see this]



	Min. Income	Average Income	Max. Income
Option A	$1,500	$3,750	$6,000
Option B	$2,730	$3,410	$4,090

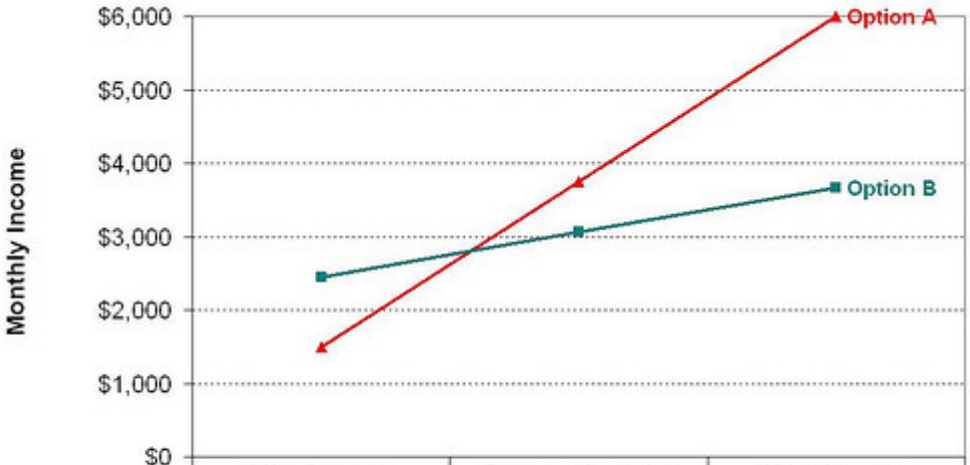
*

Which national income distribution option would you prefer?
Please choose **only one** of the following:

- ☐ **Option A**
- ☐ **Option B**
- ☐ I choose not to answer

Q.I.N.3.3:
Question 3.

[Only respondents who answered '**Option A**' to question 'Q.I.N.2.2 ' see this]



	Min. Income	Average Income	Max. Income
Option A	$1,500	$3,750	$6,000
Option B	$2,450	$3,060	$3,670

*

Which national income distribution option would you prefer?
Please choose **only one** of the following:

- ☐ **Option A**
- ☐ **Option B**
- ☐ I choose not to answer

Q.I.N.3.4:
Question 3.
[Only respondents who answered '**Option B**' to question 'Q.I.N.2.2 ' see this]

	Min. Income	Average Income	Max. Income
Option A	$1,500	$3,750	$6,000
Option B	$1,940	$2,425	$2,910

Which national income distribution option would you prefer?
Please choose **only one** of the following:

- ☐ **Option A**
- ☐ **Option B**
- ☐ I choose not to answer

Survey Section 3: Income Distribution (Global)

Now we are interested in your attitudes towards the distribution between rich and poor on a global level.

How much total global income should be sacrificed to achieve a more equal distribution?

The format of these questions is the same as in the previous section, and the same assumptions apply.

The incomes are adjusted for purchasing power, so that one dollar buys the same amount of goods in every country.

Again, assume that your position in the global income distribution is

approximately the same as it is in reality.

Remember, there is no 'correct' answer to these questions, and we ask you to reflect on the choices carefully. If you change your mind along the way, you may of course change your earlier responses.

There are three questions in this section.

Q.I.G.1:
Question 1.

*

Question 1.

	Min. Income	Average Income	Max. Income
Option A	$50	$825	$1,600
Option B	$206	$516	$826

Which global income distribution option would you prefer?
Choose only one of the following

Option A

Option B

I choose not to answer

? Assumptions:

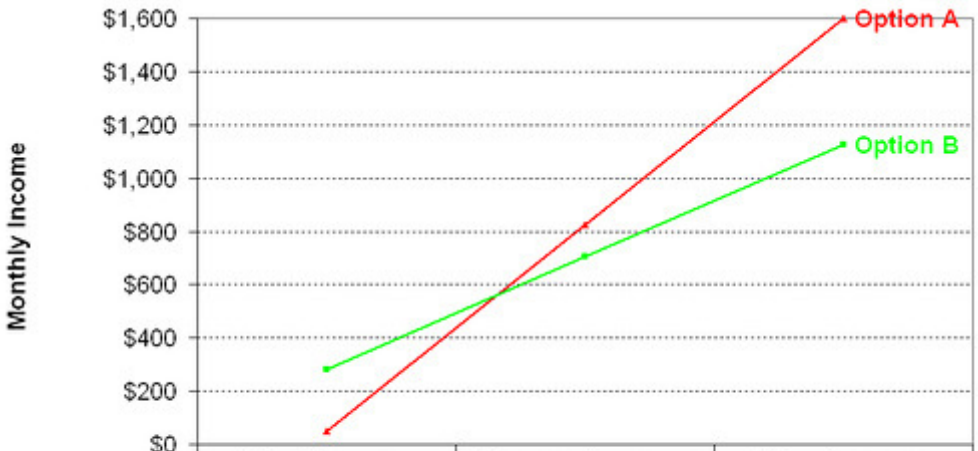
There are no social programs or international aid to help the poorest people, and everyone has to pay for their own education, health care, etc.

The richest 10% and the poorest 10% of people lie outside the stated range. Assume that these people are unaffected by your choice of distribution; your decision affects only the middle 80% of the population.
Within the stated range, people are distributed evenly, so that there is the same number of people in the upper and the lower half of the distribution.

The options differ only in terms of their income distribution, and this distribution does not affect the future growth rate of the global economy.

Question 2.

[Only respondents who chose 'Option A' in the first question see this]



	Min. Income	Average Income	Max. Income
Option A	$50	$825	$1,600
Option B	$282	$705	$1,127

Which global income distribution option would you prefer?

Choose only one of the following

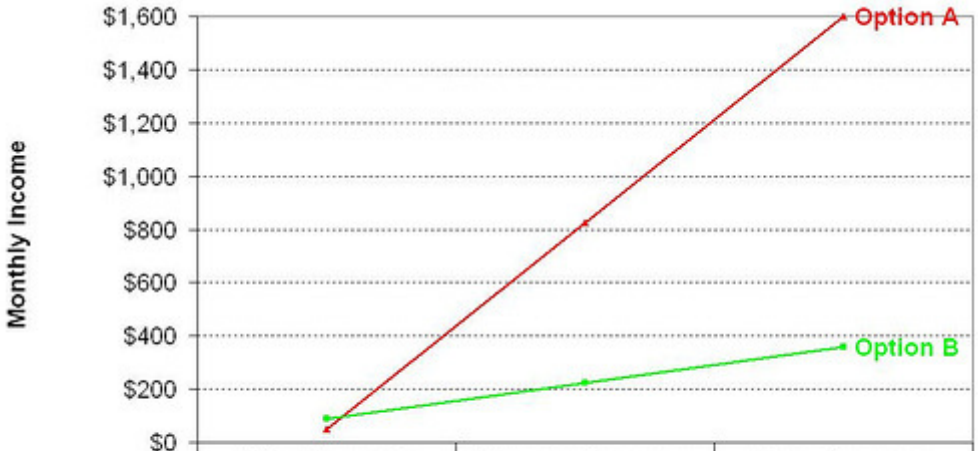
Option A

Option B

I choose not to answer

Question 2.

[Only respondents who chose 'Option B' in the first question see this]



	Min. Income	Average Income	Max. Income
Option A	$50	$825	$1,600
Option B	$89	$223	$357

Which global income distribution option would you prefer?

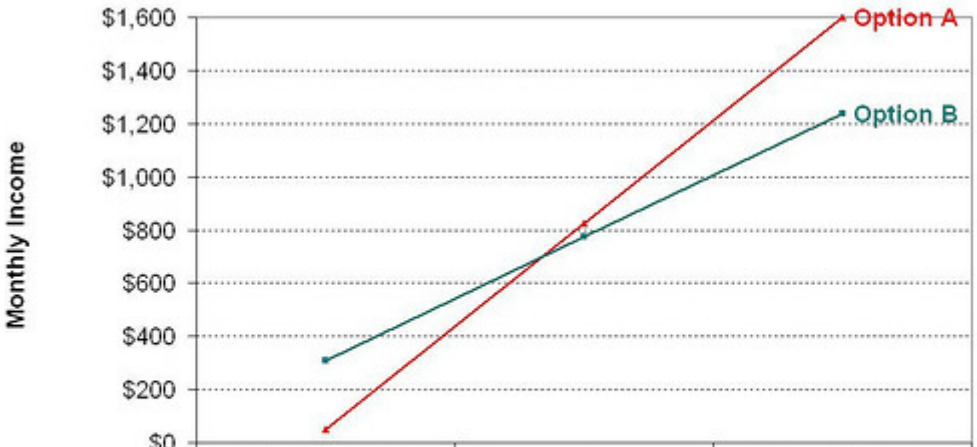
Choose only one of the following

Option A

Option B

I choose not to answer

Question 3.
[Only respondents who chose 'Option A' in the first question and 'Option A' in the second question see this]



	Min. Income	Average Income	Max. Income
Option A	$50	$825	$1,600
Option B	$310	$774	$1,238

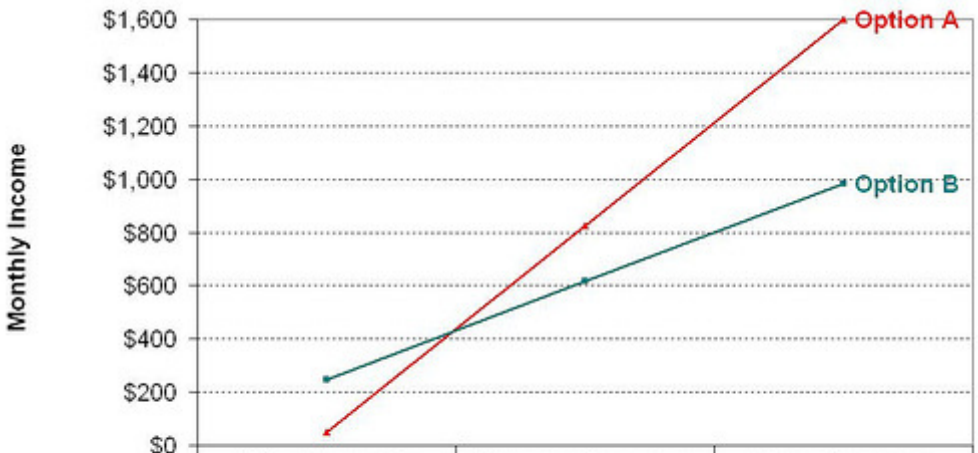
Which global income distribution option would you prefer?
Choose only one of the following

Option A

Option B

I choose not to answer

Question 3.
[Only respondents who chose 'Option A' in the first question and 'Option B' in the second question see this]



	Min. Income	Average Income	Max. Income
Option A	$50	$825	$1,600
Option B	$246	$616	$985

Which global income distribution option would you prefer?

Choose only one of the following

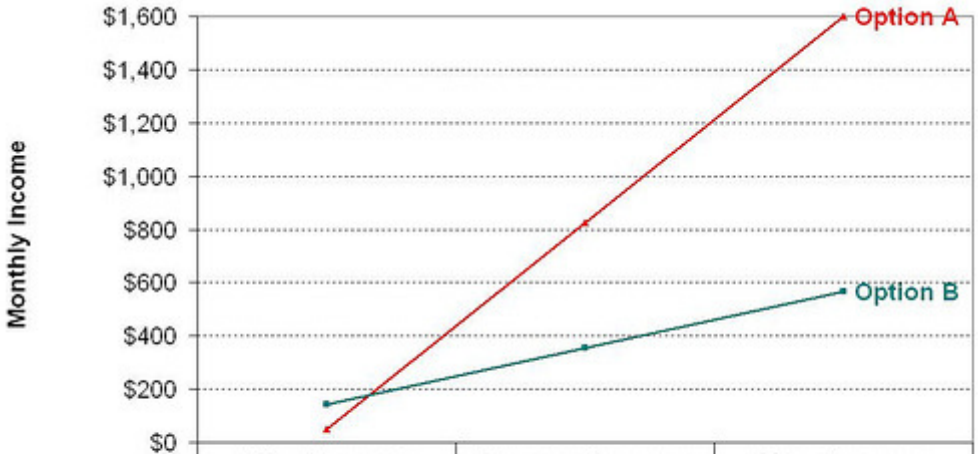
Option A

Option B

I choose not to answer

Question 3.

[Only respondents who chose 'Option B' in the first question and 'Option A' in the second question see this]



	Min. Income	Average Income	Max. Income
Option A	$50	$825	$1,600
Option B	$141	$354	$566

Which global income distribution option would you prefer?

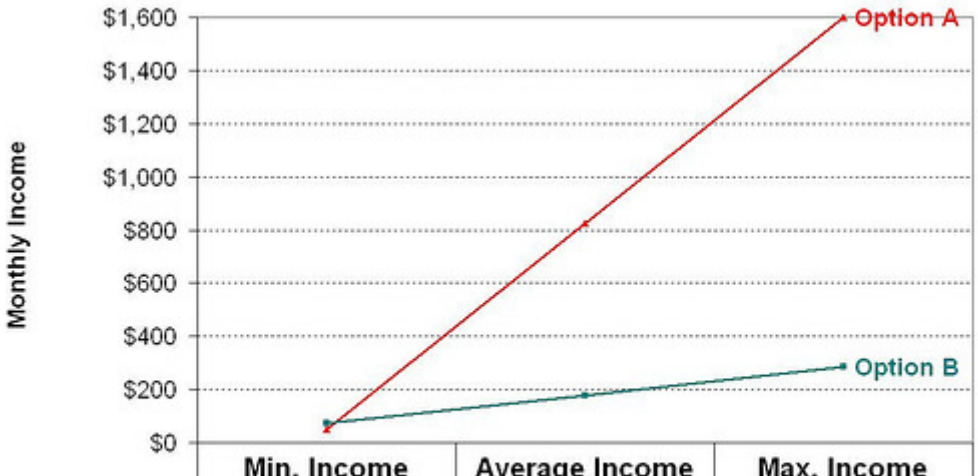
Choose only one of the following

Option A

Option B

I choose not to answer

Question 3.
[Only respondents who chose 'Option B' in the first question and 'Option B' in the second question see this]



	Min. Income	Average Income	Max. Income
Option A	$50	$825	$1,600
Option B	$72	$179	$286

Which global income distribution option would you prefer?
Choose only one of the following

Option A

Option B

I choose not to answer

Survey Section 5: Societal Risk

Now we are interested in your attitudes toward risk on a national level.
The format of this section is the same as in the previous section.

Governments make many kinds of choices that affect our standard of living. In many cases, the effect of these choices is uncertain. Some policies have the potential to increase our standard of living, but on the other hand these policies may also increase the risk that our living standards will fall.

For example, by spending less on flood defenses, more money could be spent on other infrastructure, like roads and schools, thereby increasing economic growth. The drawback of spending less on defenses is that if a flood occurs, economic losses are likely to be greater as a result of this policy.

Suppose that the government can guarantee that the current average national income is sustained forever. But it also has the opportunity to make policies that

give a 50-50 chance of doubling the national average income. On the other hand, each of these policies also has a 50-50 chance of cutting the current average national income by a given amount.

In each question you will be asked whether you would vote for such a policy.

Assume that there is no inflation.

There are three questions in this section.

Question 1.

Suppose that the government can guarantee that the current average national income is sustained forever.

But it has the opportunity to make a policy that gives a 50-50 chance of doubling the national average income.
On the other hand, the proposed policy also has a 50-50 chance of cutting the current average national income by 33%.

Would you be willing to have the government adopt such a policy?

- ○ Yes
- ○ No
- ◉ No answer

Question 2.
[Only respondents who answered 'Yes' to the first question see this]
Suppose that the government can guarantee that the current average national income is sustained forever.

But it has the opportunity to make a policy that gives a 50-50 chance of doubling the national average income.
On the other hand, the proposed policy also has a 50-50 chance of cutting the current average national income by 50%.

Would you be willing to have the government adopt such a policy?

- ○ Yes
- ○ No
- ◉ No answer

Question 2.
[Only respondents who answered 'No' to the first question see this]

Suppose that the government can guarantee that the current average national income is sustained forever.

But it has the opportunity to make a policy that gives a 50-50 chance of doubling the national average income.
On the other hand, the proposed policy also has a 50-50 chance of cutting the current average national income by 15%.

Would you be willing to have the government adopt such a policy?

- ☐ Yes
- ☐ No
- ◉ No answer

Question 3.
[Only respondents who answered 'Yes' to the first question and 'Yes' to the second question see this]

Suppose that the government can guarantee that the current average national income is sustained forever.

But it has the opportunity to make a policy that gives a 50-50 chance of doubling the national average income.
On the other hand, the proposed policy also has a 50-50 chance of cutting the current average national income by 66%.

Would you be willing to have the government adopt such a policy?

- ☐ Yes
- ☐ No
- ◉ No answer

Question 3.
[Only respondents who answered 'Yes' to the first question and 'No' to the second question see this]

Suppose that the government can guarantee that the current average national income is sustained forever.

But it has the opportunity to make a policy that gives a 50-50 chance of doubling the national average income.
On the other hand, the proposed policy also has a 50-50 chance of cutting the current average national income by 40%.

Would you be willing to have the government adopt such a policy?

- ☐ Yes
- ☐ No
- ◉ No answer

Question 3.
[Only respondents who answered 'No' to the first question and 'Yes' to the second question see this]

Suppose that the government can guarantee that the current average national income is sustained forever.

But it has the opportunity to make a policy that gives a 50-50 chance of doubling the national average income.
On the other hand, the proposed policy also has a 50-50 chance of cutting the current average national income by 25%.

Would you be willing to have the government adopt such a policy?

- ☐ Yes
- ☐ No
- ◉ No answer

Question 3.
[Only respondents who answered 'No' to the first question and 'No' to the second question see this]

Suppose that the government can guarantee that the current average national income is sustained forever.

But it has the opportunity to make a policy that gives a 50-50 chance of doubling the national average income.
On the other hand, the proposed policy also has a 50-50 chance of cutting the current average national income by 10%.

Would you be willing to have the government adopt such a policy?

- ☐ Yes
- ☐ No
- ◉ No answer

Survey Section 6: Time

Some of the policies adopted by governments affect how the standard of living will change in the future. Many of these policies can be thought of in a way similar to your own decisions on how much to spend and how much to save.

Some policies can increase future income quite a lot by sacrificing only a small amount of income today. Other policies require large cuts now for modest gains in the future.

How should the living standard in one period be weighed against the living

standards in another period?

The following questions ask you to choose between government saving and spending plans that cover the period Now-2107 and 2107-2207.

Assume that there is no inflation.

Remember, there is no 'correct' answer to these questions, and we ask you to reflect on the choices carefully. If you change your mind along the way, you may of course change your earlier responses.

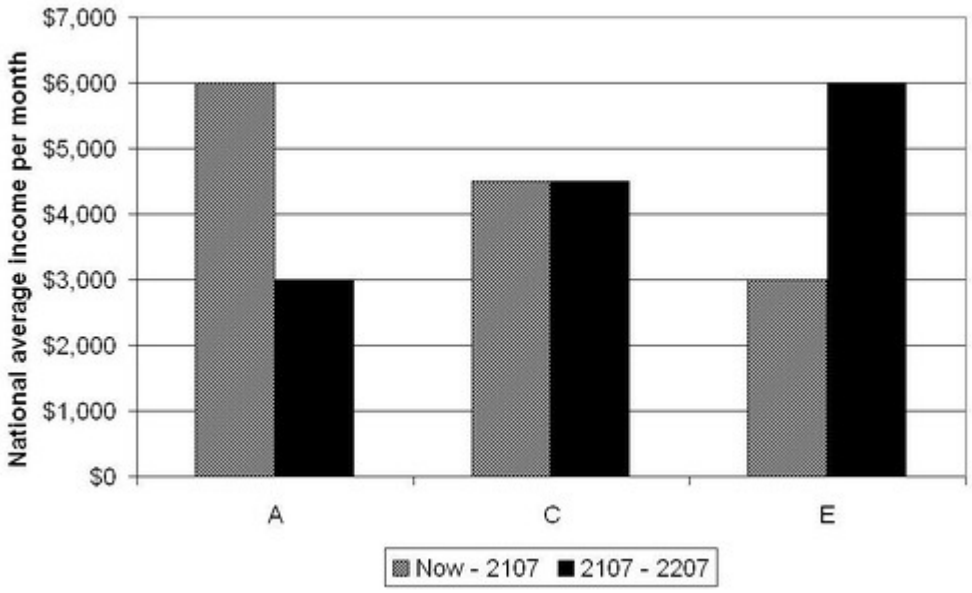
There are four questions in this section.

Question 1.

This question contains several possible ways in which standards of living could change over the next two hundred years.

Government policies to save and invest today will ensure that future generations have a higher standard of living next century, as in choice E.
Or government could encourage more borrowing and spending this century, spending less next, as in choice A.
Or government policies could aim for a constant standard of living, as in choice C.

In this first question, saving $1 in the first period means that income in the second period increases by $1.



PLAN	A	C	E
NOW-2107	$6000	$4500	$3000
2107-2207	$3000	$4500	$6000

Which plan do you prefer?
Choose only one of the following

A

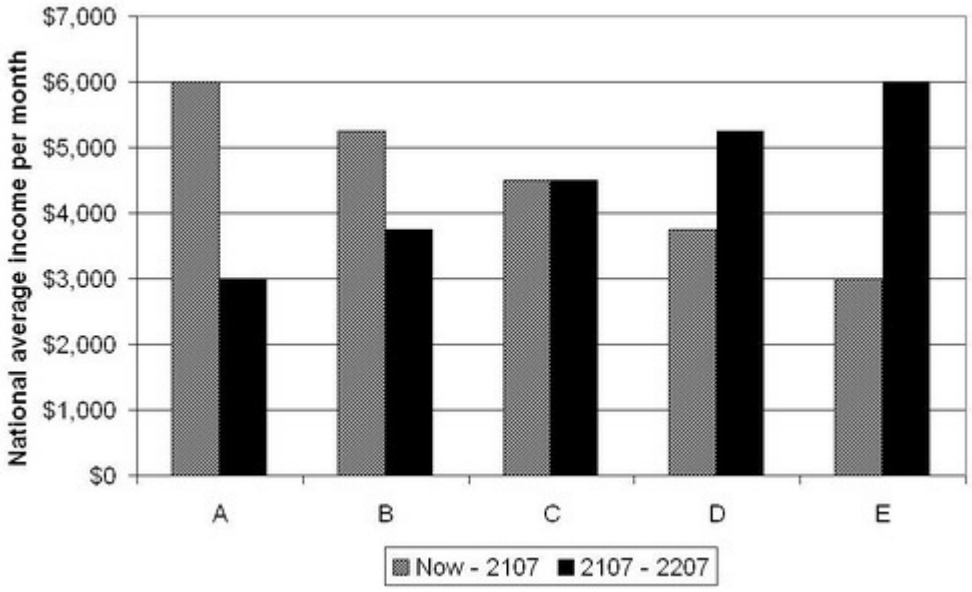
C

E

I choose not to answer

Question 2.

Here are the same plans as before, but with two additional choices.



PLAN	A	B	C	D	E
NOW-2107	$6000	$5250	$4500	$3750	$3000
2107-2207	$3000	$3750	$4500	$5250	$6000

Which plan do you prefer?
Choose only one of the following

A

B

C

D

E

I choose not to answer

Question 3.

Here is another set of plans.
Saving $1 in the first period means that income in the second period increases by $4.

PLAN	A	B	C	D	E
NOW-2107	$5250	$4875	$4500	$4125	$3750
2107-2207	$1500	$3000	$4500	$6000	$7500

Which plan do you prefer?
Choose only one of the following

A

B

C

D

E

I choose not to answer

Question 4.

Finally, in this last set of plans, saving $1 in the first period means that income in the second period increases by $0.25

PLAN	A	B	C	D	E
NOW-2107	$7500	$6000	$4500	$3000	$1500
2107-2207	£3750	$4125	$4500	$4875	$5250

Which plan do you prefer?
Choose only one of the following

A

B

C

D

E

I choose not to answer

Survey Section 7: Demographics

In the following section we ask you to answer some basic demographic information.
As before, the responses are confidential and anonymous.
We seek this information solely for the purpose of analysis of the data obtained in the first sections of this survey.

There are nine questions in this section.

Q.D.1:
Question 1.

Please specify your gender:
Please choose **only one** of the following:

- ☐ Female
- ☐ Male

Q.D.2:
Question 2.

Please specify the year of your birth

Use a 4-digit format i.e. 1901; only years of the form: 19XX will be accepted.

Please write your answer here:

Q.D.4:
Question 4.

What is your average total household income annually?
(Please include the income of all earners in your household before taxes.)

Remember that these responses are anonymous and confidential.

Please choose **only one** of the following:

- ☐ <$15000
- ☐ $15000-$29999
- ☐ $30000-$44999
- ☐ $45000-$59999

- ☐ $60000-$74999
- ☐ $75000-$89999
- ☐ $90000-$99999
- ☐ $100000-$119999
- ☐ $120000-$129999
- ☐ $130000-$139999
- ☐ $140000-$159999
- ☐ $160000-$174999
- ☐ $175000-$189999
- ☐ $190000-$199999
- ☐ $200000-$219999
- ☐ $220000-$299999
- ☐ $300000-$349999
- ☐ $350000-$449999
- ☐ >$450000

Q.D.5:
Question 5.

Which option best describes your highest level of education completed?
Please choose **only one** of the following:

- ☐ Some high school or less
- ☐ High School Graduate
- ☐ College/University Undergraduate Degree
- ☐ Post-Graduate Degree (Master or PhD)
- ☐ Medical (doctor) Degree
- ☐ Law Degree

Q.D.6:
Question 6.

What is your current employment status?
Please choose **only one** of the following:

- ☐ Full-time private sector
- ☐ Full-time public sector
- ☐ Self-employed
- ☐ Leave (paid)
- ☐ Leave (other)

- ☐ Retired
- ☐ Taking care of the house (homemaker)
- ☐ Student
- ☐ Unemployed

Q.D.9:
Question 9.

Are you a member of an environmental organization or conservation group?
Please choose **only one** of the following:

- ☐ Yes
- ☐ No

Appendix II: E-mail lists through which the survey was distributed

- Environment & Ethics List, University of Oxford
- Green College students & staff, University of Oxford
- Linacre College students & staff, University of Oxford
- Physics Department, University of Oxford.
- MSc Environmental Change and Management Alumni List, University of Oxford
- Fulbright Academy of Science & Technology, July 2007 On-Line Newsletter
- US National Institute of Standards and Technology, Office of Applied Economics
- SPIRE, Norwegian University of Life Sciences
- RESECON (Land & Resource Economics Network)
- EARTHNOTES, Brandeis University
- Parent Heart Watch, USA
- Climate Change Information Mailing List, IISD

Appendix III: Tables of Results

Table 4.2: Frequency distribution Relative Risk Aversion

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	<0.5	80	2.5	2.9	2.9
	0.5-1.0	114	3.6	4.1	7.0
	1.0-1.5	114	3.6	4.1	11.2
	1.5-2.0	467	14.9	17.0	28.2
	2.0-3.0	136	4.3	4.9	33.1
	3.0-5.0	890	28.3	32.3	65.4
	5.0-7.5	387	12.3	14.1	79.5
	>7.5	565	18.0	20.5	100.0
	Total	2753	87.7	100.0	
Missing		387	12.3		
Total		3140	100.0		

Table 4.3: Relative Inequality Aversion (National)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	<0.5	647	20.6	23.0	23.0
	0.5-1.0	97	3.1	3.4	26.4
	1.0-1.5	83	2.6	3.0	29.4
	1.5-2.0	125	4.0	4.4	33.8
	2.0-3.0	244	7.8	8.7	42.5
	3.0-5.0	269	8.6	9.6	52.1
	5.0-7.5	325	10.4	11.6	63.6
	>7.5	1023	32.6	36.4	100.0
	Total	2813	89.6	100.0	
Missing		327	10.4		
Total		3140	100.0		

Table 4.4 Relative Inequality Aversion (Global)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	<0.5	397	12.6	14.3	14.3
	0.5-1.0	151	4.8	5.4	19.7
	1.0-1.5	168	5.4	6.0	25.8
	1.5-2.0	197	6.3	7.1	32.9
	2.0-3.0	509	16.2	18.3	51.2
	3.0-5.0	343	10.9	12.3	63.5
	5.0-7.5	162	5.2	5.8	69.3
	>7.5	852	27.1	30.7	100.0
	Total	2779	88.5	100.0	
Missing		361	11.5		
Total		3140	100.0		

Table 4.6: Correlations

			Relative Inequality Aversion (National)	Relative Inequality Aversion (Global)	Relative Risk Aversion	Elasticity of Intertemporal Substitution (Midpoint)	Desired slope of consumption path at r=0 (Midpoint)
Kendall's tau_b	Relative Inequality Aversion (National)	Correlation Coefficient	1.000	.510(**)	.129(**)	-.124(**)	.010
		Sig. (2-tailed)	.	.000	.000	.000	.569
		N	2813	2679	2562	2295	2295
	Relative Inequality Aversion (Global)	Correlation Coefficient	.510(**)	1.000	.133(**)	-.123(**)	.020
		Sig. (2-tailed)	.000	.	.000	.000	.224
		N	2679	2779	2546	2269	2269
	Relative Risk Aversion	Correlation Coefficient	.129(**)	.133(**)	1.000	-.069(**)	-.049(**)
		Sig. (2-tailed)	.000	.000	.	.000	.004
		N	2562	2546	2753	2249	2249
	Elasticity of Intertemporal Substitution (Midpoint)	Correlation Coefficient	-.124(**)	-.123(**)	-.069(**)	1.000	-.202(**)
		Sig. (2-tailed)	.000	.000	.000	.	.000
		N	2295	2269	2249	2461	2461
	Desired slope of consumption path at r=0 (Midpoint)	Correlation Coefficient	.010	.020	-.049(**)	-.202(**)	1.000
		Sig. (2-tailed)	.569	.224	.004	.000	.
		N	2295	2269	2249	2461	2461

** Correlation is significant at the 0.01 level (2-tailed).

Table 4.7: 'The effects of climate change will pose serious risks to global society during the remainder of your lifetime'

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	112	3.6	3.6	3.6
	Disagree	183	5.8	5.9	9.6
	Neither Agree nor Disagree	197	6.3	6.4	16.0
	Agree	1048	33.4	34.0	50.0
	Strongly Agree	1541	49.1	50.0	100.0
	Total	3081	98.1	100.0	
Missing		59	1.9		
Total		3140	100.0		

Table 4.9: Relative Risk Aversion (weighted)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	<0.5	105	3.4	4.1	4.1
	0.5-1.0	88	2.8	3.5	7.6
	1.0-1.5	95	3.1	3.8	11.4
	1.5-2.0	389	12.6	15.4	26.8
	2.0-3.0	90	2.9	3.6	30.4
	3.0-5.0	838	27.1	33.2	63.6
	5.0-7.5	376	12.2	14.9	78.5
	>7.5	543	17.5	21.5	100.0
	Total	2523	81.6	100.0	
Missing	System	571	18.4		
Total		3093	100.0		

Table 4.10: Relative Inequality Aversion (National) (weighted)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	<0.5	781	25.2	29.6	29.6
	0.5-1.0	109	3.5	4.1	33.8
	1.0-1.5	116	3.8	4.4	38.2
	1.5-2.0	138	4.4	5.2	43.4
	2.0-3.0	272	8.8	10.3	53.7
	3.0-5.0	186	6.0	7.1	60.8
	5.0-7.5	266	8.6	10.1	70.9
	>7.5	767	24.8	29.1	100.0
	Total	2634	85.2	100.0	
Missing	System	459	14.8		
Total		3093	100.0		

Table 4.11: Results of K-S tests (weigthed)

	National ηI	**Global ηI**	**ηr**	**ηt**
National ηI		15.2%	28.8%	49.6%
Global ηI	15.2%		22.6%	48.4%
ηr	28.8%	22.6%		50.0%
ηt	49.6%	48.4%	50.0%	

Appendix IV: Derivation of weights

Sample distribution

Highest level of education attained				
	Response	*Equivalent level*	*Percent*	*Valid Percent*
Valid	Some High School or Less	No qualification or Level 1*	5	6
	High School Graduate	Level 2**/3***	19	20
	Undergraduat Degree	Level 4/5#	43	44
	Postgraduate Degree	Level 4/5#	27	28
	Medical (Doctor) Degree	Level 4/5#	1	1
	Law Degree	Level 4/5#	2	2
	Total		99	100
Missing			1	
Total			100	

Population distribution in England and Wales

Highest level of education attained				
	Equivalent level	*Frequency*	*Percent*	*Valid Percent*
Valid	No qualification	10,937,042	29	31
	Level 1*	6,230,033	17	18
	Level 2**	7,288,074	19	21
	Level 3***	3,110,135	8	9
	Level 4/5#	7,432,962	20	21
	Total	34998246	93	100
Missing		2,609,192	7	
Total		37607438	100	

Source: Office of National Statistics (2004)

* 1+ 'O' level passes; 1+ CSE/GCSE any grades; NVQ level 1; Foundation GNVQ.

** 5+ 'O' level passes; 5+ CSEs (grade 1's); 5+ GCSEs (grades A-C); School Certificate; 1+ 'A' levels/'AS' levels; NVQ level 2; Intermediate GNVQ.

*** 2+ 'A' levels; 4+ AS levels; Higher School Certificate; NVQ level 3; Advanced GNVQ.

First degree; Higher degree; NVQ levels 4 and 5; HNC; HND; Qualified Teacher Status; Qualified Medical Doctor; Qualified Dentist; Qualified Nurse; Midwife; Health Visitor.

Formula for calculating weights

$$(IV.1) \quad Weight = \frac{Population\ \ proportion\ \ (valid\ \ \%)}{Sample\ \ proportion\ \ (valid\ \ \%)}$$

Weights

Response	*Weight*
Some High School or Less	8.875
High School Graduate	1.522
Undergraduat Degree	0.283
Postgraduate Degree	0.283
Medical (Doctor) Degree	0.283
Law Degree	0.283