Climate Change Catastrophes and Insuring Decisions: A Study in the Presence of Ambiguity*

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Abstract

There has been very little research to test whether ambiguity affects individuals' decisions to insure themselves against the catastrophic effects of climate change. This paper attempts to study how individuals respond to the availability of an insurance that would safeguard their interests if a climate change catastrophe occurred. Moreover, if such an insurance is available to them, do they insure themselves sufficiently? Further, the study investigates if increased information regarding the probability of the catastrophic event, leads to an increase in insurance subscriptions. Finally, policy implications for the State are investigated - Can State intervention in the form of a "nudge" ensure a better outcome?

Keywords: Climate change catastrophes; insurance; ambiguity; Choquet expected utility; strategic substitutes; lemons market; nudge.

JEL Classification: **C**71, **C**91, **D**03, D81, Q54

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1 Introduction

The United Nations Framework Convention on Climate Change (1994), defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." Industrialisation and growing population rates have resulted in an increase in CO_2 and other greenhouse gas levels in the atmosphere, causing global warming. If emissions are allowed to continue unabated at their current rates, it would lead to irreversible changes in the Earth's climate. Climate change related catastrophes such as flooding, storms and other extreme weather-related events are predicted to occur more frequently and with greater damage-causing intensity. Climate change is a global challenge and one that presents at a level of severity and scale that is unprecedented.

There is a growing body of economic studies on climate change. Stern (2006) is one of the most significant studies that analyses the market failures caused by climate change and proposes a range of mechanisms including environmental taxes to minimise the economic and social disruptions caused by climate change. McKibbin & Wilcoxen (2002) consider the role of economics in climate change policy and suggest the use of a hybrid model that incorporates the best features of tradable permits and emissions taxes. A number of studies have been conducted that analyse permit trading in the context of climate change (see Bohm & Carlen (2002), Cramtom & Kerr (2002), Altamirano-Cabrera & Finus (2006), Wråke *et al.* (2008)), while the case for taxing green house gas emissions is considered by Metcalf (2007), Avi-Yonah & Uhlmann (2009), Gerlagh *et al.* (2009) among others. There have also been studies that consider the behavioral economics of climate change, in particular, the implications of prospect theory, the equity premium puzzle and time inconsistent preferences in the choice of discount rate used in climate change cost assessments (for a detailed analysis see Brekke & Johansson-Stenman (2008)). This stream of research also benefits from experimental studies that have investigated reciprocity (Fehr & Gächter (2000), Falk & Fischbacher (2006)), trust (Gächter *et al.* (2004)), altruism (Gowdy (2008)) and conditional cooperation (Fischbacher *et al.* (2001)).

Further, there have been studies that investigate individual behaviour regarding climate change to determine whether communication (Milinski *et al.* (2008)), fairness and differences in endowment levels (Tavoni *et al.* (2011)), affect how individuals coordinate to try and prevent climate change catastrophes. Barrett & Dannenberg (2012) investigate whether uncertainty about climate change affects international cooperation, by modelling climate negotiations as a coordination game. The study explains why countries often agree to a collective goal that would reduce the risk of a catastrophe, but then behave like they were blind to this risk.

There exists a great deal of ambiguity surrounding climate change and the possibility that this climate change could at any point trigger a catastrophe. A climate change catastrophe can be viewed as a low-probability high-impact event that causes wide-scale damage. Given the ambiguity[1] surrounding a catastrophic event taking place, it would be interesting to investigate whether people are sufficiently concerned in order to insure themselves against it. Moreover, if given the opportunity to protect themselves against such a catastrophe, do individuals sufficiently insure themselves?

Insurance is a market-based mechanism that transfers risk. Insurers have successfully facilitated the pooling and transfer of risk for centuries. Risks that would be impossible for individuals or corporations to bear on their own have been managed through the insurance (and re-insurance) market. Two main types of insurance are currently present in the market: life insurance and general insurance. Life insurance policies are dependant on mortality risk forecasts and long-term saving rates, and can last several decades with asset-matched liabilities that mature on similarly long time horizons. General insurance, on the other hand, provides cover for a large range of possible damage-causing events. Some of the liabilities covered by general insurance policies may have long tails (for instance, asbestos related claims), with claims being made many years after the insured event (Prudential Regulation Authority (2015)).

Climate change poses a very real and significant challenge to the insurance market, especially when considering the long-term nature (or long tail) of possible claims. Intuitively, weather-related

[1] When a decision-maker fails to assign a subjective probability to an event, ambiguity arises.

events would be covered by general insurance policies, however, depending on the severity of the event, it may also result in life insurance liabilities. The impact of climate change may cause a disruption to the existing insurance arrangements, and as such, creates important issues for public policy. Consider the case of Dawlish, a small village in the county of Devon, UK. In February 2014, parts of southern Britain were hit by a severe storm, that led to the collapse of a section of the sea wall in Dawlish and left the railway to Cornwall suspended in mid-air. The storm also affected residents in nearby Somerset, who were evacuated amid fears that flood defences could be overwhelmed. The government at the time pledged an extra £100m for flood works. In addition, the government set up a "Flood Grants Scheme" that would provide grants for homeowners in England hit by floods. The scheme was to provide claimants up to £5,000, to help cover *future* protection for properties. However, it did not cover the damage or losses already suffered. Dawlish has since been struck by storms again in 2015 and 2016.

The Environment Agency's 2008 National Flood Risk Assessment reported that there were 2.4 million properties in England, that were at risk of flooding from rivers and the sea, while a further 2.8 million properties were prone to surface water flooding. In total, approximately 5.2 million properties in England alone, or one in six properties, was considered to be at risk of flooding. In monetary terms, the expected annual damages this would cause to residential and non-residential properties in England is estimated to exceed £1 billion (Environment Agency (2009)).[2] In addition, flooding also indirectly impacts key services such as energy, water, communications and transport infrastructure.

The correlation between the estimated risks caused by climate events and the increased frequency with which they are forecast to occur in the future, create a number of implications for insurance firms' choice of risk diversification and capital requirements. While the traditional general insurance market could adapt to such changes caused by the expected increase in climate events, governments may decide that the provision of insurance cover has many elements of a public good. State involvement

[2] Another example of damage caused by flooding can be seen in Thailand, where floods have been estimated to have caused US$45 billion of economic damage, and further costed US$12 billion of insurance payments including claims arising from second-order effects (See Prudential Regulation Authority (2015)).

in providing flood insurance to residential and non-residential properties is already common. Many countries have put public-private or government-funded schemes in place. These schemes imply that many governments consider the provision of insurance cover to be a pseudo-public good and as such recognise the need to support home and business owners in building up their resilience (Prudential Regulation Authority (2015)).

Public goods are goods which once provided, can be consumed by everybody. Due to the collective nature of a public good, everybody derives equal utility from its provision, irrespective of their own contribution towards it. The usual assumption made with regards to public good provision is that the amount of the public good available is a function of the *sum* of all individual contributions. For an extensive survey of the literature on public goods, see Ledyard (1995). Ambiguity in the standard public goods model has been previously studied in Eichberger & Kelsey (2002) and Bailey *et al.* (2005). Weakest-link/best-shot versions of the public good game with strategic uncertainty have been studied by Kelsey & le Roux (2016). Dannenberg *et al.* (2015) analyse whether uncertainty regarding the level of the threshold affects collective action in threshold public goods games.

This paper combines experimental and theoretical research to study the effects of climate change related ambiguity on individuals' contribution decisions in a *threshold* public goods game. The threshold public goods nature of climate change related insurance can be illustrated as follows: consider a small community that must build sea/river defences to protect itself from flooding. The community begins an initiative to gather funds in order to build a dyke. Once the dyke is built, it ensures that everyone in the community is safe from flooding (irrespective of personal contributions). However, in order for the dyke to be constructed, a certain threshold of contributions needs to be reached. In other words, a threshold public goods game arises, where a minimum amount of contributions needs to be collected from a group of individuals for provision to occur. In this example, climate change "insurance" contributions are being used to adapt and mitigate the effects of a climate change catastrophe *directly.*

More indirectly, contributing to the insurance could be seen as a method of cross-insuring across different geographical locations, such that if a catastrophe occurred, any losses suffered would be financially compensated. However, only if subscriptions to the insurance are sufficiently cross-insured between different regions, will it be viable for an insurance company to provide such insurance. Thus, a contribution threshold needs to be reached in order to make it viable for the insurance company to provide cover.

The objective of the game being studied is thus to avoid a loss due to a weather-related catastrophe, unlike a regular public goods game where the objective is to create a gain.[3] Subjects who take part in the game are given an endowment and warned that they might be the victim of a climate change catastrophe. The catastrophe which occurs with some unknown probability,[4] would result in them losing their endowment. They can safeguard themselves against such a loss, by contributing as a *group* towards insurance. The insurance is bought if a threshold is reached and safeguards the team as a whole in the event of a catastrophe taking place.

Each subject's contribution towards attaining the insurance may be viewed as a strategic substitute for the others'. In the presence of ambiguity, if a player thinks that the others in his group would not contribute towards the public good, it should prompt him to increase his own contribution, in order to buy the insurance and avoid catastrophic climate change. It is thus possible to get a theoretical prediction of subject behaviour, given that there is a clear worst case scenario – failure to buy the insurance and a loss due to catastrophic climate change.

If it is found that individuals fail to sufficiently safeguard themselves (i.e., the threshold is not reached), it might indicate that they do not regard the climate change catastrophe as very likely - that is, a very low probability is attached to such an event. Another reason for the threshold not being reached might be that subjects have not fully considered the likelihood/magnitude of a climate change catastrophe. It might be that giving them information about the increasing frequency/damage caused by such events in related areas, could help in improving contributions. This would test whether

[3]See Milinski *et al.* (2008), Tavoni *et al.* (2011), Barrett & Dannenberg (2012) for similar games.

[4]The probability with which the catastrophe would occur was unknown even to the experimenter and was determined by a random generator on z-Tree.

better access to information results in increased subscriptions.

It has been seen in the past that individuals discount the future to a great extent, and as such fail to make sufficient provisions for the future. The most prominent example of this myopic discounting is the thousands of people who found they did not have a pension to support them when they retired. In 2013, the UK Government introduced the first nationwide automatic enrolment, where employers had to compulsorily enrol all employees into a workplace pension scheme. Employees could then choose to leave if they wished. Cribb & Emmerson (2016) find that the automatic enrolment resulted in the number of private sector workers participating in workplace pensions to have increased by 37%, while workplace pension membership as a whole reached 88% by April 2015.

The insight that this government "nudge" provided, is that changing the default pension enrolment status could overcome behavioural biases that resulted in people failing to optimally save for their future. Extending the insight to the current study it would be interesting to investigate whether the State should intervene if individuals fail to make adequate provision to insure themselves against the risk of a climate change catastrophe. Moreover, would a State intervention ensure a better (more optimal) outcome?

2 Experimental Model and Equilibrium

The experimental setup in the current study makes use of *two* players, since this makes it possible to calculate the theoretical equilibrium under ambiguity and the predicted contribution levels in the presence of ambiguity. The design thus consists of two players, each given an endowment of $30ECU$, who play five rounds. In each round a player had the choice of contributing between $0 - 4$ ECU (they could make discrete contributions of $0, 1, 2, 3$ or $4ECU$) with the aim of getting a total joint contribution of $20ECU$, at the end of the five rounds. If at the end of the rounds, the players managed to reach the $20ECU$ threshold, they safeguarded themselves against the harmful impact of a climate change catastrophe. If they failed to reach the threshold, a climate change catastrophe may have occurred with some unknown probability, and the players lost all their money.

Subjects were randomly matched into groups of two, and remained in the same group throughout the experiment. Subjects were not allowed to communicate with each other and no information about intermediate contribution levels was made available to subjects between rounds. As such, subjects would perceive ambiguity from two sources:

1) The interaction with other players - which results in ambiguity about the other subject's choice of contribution levels (endogenous ambiguity).

2) Ambiguity caused because of the unknown probability with which climate change catastrophe may or may not occur (exogenous ambiguity).

2.1 Nash equilibrium

The game has two symmetric pure strategy equilibria: One, where each player contributes a total of $10ECU$ over the five rounds (or $2ECU$/round), the safety threshold is reached and each player has a guaranteed final payoff of $20ECU$. Second, where each player contributes nothing each round, they fail to reach the threshold, and each has an expected payoff of $6ECU$.[5] It is clearly optimal for each player to contribute $10ECU$ over the five decision rounds, which makes this the more efficient symmetric equilibrium strategy.

Alternatively, if asymmetric coordination is considered, any combination of contributions from the two players which is equal to the threshold level of $20ECU$ is a Nash equilibrium. In essence, there is no difference between the efficient symmetric equilibrium and the asymmetric equilibria. However, both contributing more and contributing less than necessary to reach the threshold, is inefficient.

2.2 Equilibrium under Ambiguity

In a Nash equilibrium, players are believed to behave in a manner that is consistent with the actual behaviour of their opponents. They are perfectly able to predict the actions of their opponent and

[5] The expected payoff when the threshold is not reached $= (0.8 * 0) + (0.2 * 30) = 6ECU$.

can thus provide a best response to it in the form of their own action. However, in the presence of ambiguity, the Nash concept of predicting the opponent's behaviour is no longer valid and needs to be modified. Unlike Nash equilibrium where a player can assign an additive probability distribution to his opponent's actions, in the presence of ambiguity, the beliefs of a player are represented by a neo-additive capacity: $v(A|\alpha, \delta, \pi) = \alpha\delta + (1-\delta)\pi(A)$. Neo-additive capacities were introduced by Chateauneuf *et al.* (2007), as a way of capturing non-additive probabilities. In this model the decision-maker has beliefs based on an additive probability distribution π. However the decision-maker lacks confidence in these beliefs, which are thus ambiguous beliefs. The ambiguity the decision-maker faces is represented by the parameter δ. The individual's attitude to ambiguity is represented by the parameter α, with higher values of α corresponding to greater ambiguity-aversion.

Applying the model of decision-making under ambiguity to the two-player game being studied in this paper: If n_1 is the action chosen by Player 1 and n_2 denotes the action chosen by Player 2, the payoff function measuring the Choquet Expected Utility (CEU) of Player 1 may be represented as[6]:

$$V_1(n_1; \alpha, \delta, \pi) = \delta\left[\alpha \max u_1(n_1, n_2) + (1-\alpha) \min u_1(n_1, n_2)\right] + (1-\delta) \sum u_1(n_1, n_2) \cdot \pi(n_2).$$

The CEU of a player maximises a weighted average of the best payoff, the worst payoff and the expected payoff (Schmeidler (1989)). Intuitively, π can be thought to be the decision-maker's belief. However, this is an ambiguous belief. His confidence about it is modelled by $(1-\delta_i)$, with $\delta_i = 1$ denoting complete ignorance and $\delta_i = 0$ denoting no ambiguity. His attitude to ambiguity is measured by α_i, with $\alpha_i = 1$ denoting pure pessimism and $\alpha_i = 0$ denoting pure optimism. If the decision-maker has $0 < \alpha_i < 1$, he is neither purely optimistic nor purely pessimistic (i.e., ambiguity-averse), but reacts to ambiguity in a partly pessimistic way by putting a weight on bad outcomes and in a partly optimistic way by putting a weight on good outcomes.

[6]Schmeidler (1989) proposed a theory called Choquet Expected Utility (CEU), where outcomes are evaluated by a weighted sum of utilities, but unlike Expected Utility Theory the weights used depend on the acts.

The inefficient Nash, where players contribute $0ECU$ per round and fail to reach the safety threshold has been ignored, since it is dominated by the efficient/symmetric Nash equilibrium.

In the symmetric Nash equilibrium, if Player 1 contributes $2ECU$ per round: The maximum payoff, if the threshold is reached, is $20ECU$. Else, if the threshold is not reached and the climate change catastrophe occurs, the payoff is $0ECU$. Let the probability with which Player 2 contributes $2ECU$ per round be $\tilde{\pi}_2$. The CEU of Player 1 from contributing $2ECU$ per round can be computed as:

$$\begin{aligned}\tilde{V}_1 &= \delta\left[\alpha \cdot 20 + (1-\alpha)\cdot 0\right] + (1-\delta)(20 \cdot \tilde{\pi}_2)\\ &= 20\delta\alpha + 20(1-\delta)\tilde{\pi}_2.\end{aligned}$$

If Player 1 contributes $4ECU$ per round: The threshold is always reached. Player 1, thus has a secure payoff of $10ECU$. The CEU of Player 1 from contributing $4ECU$ per round is thus: $\hat{V}_1 = 10$.

Player 1 will prefer to contribute $4ECU$ per round iff:

$$\begin{aligned}\hat{V}_1 &> \tilde{V}_1,\\ 10 &> 20\delta\alpha + 20(1-\delta)\tilde{\pi}_2\\ \frac{1}{2} &> \delta\alpha + (1-\delta)\tilde{\pi}_2.\end{aligned}$$

Based on Player 1's belief of $\tilde{\pi}_2$, $\hat{V}_1$ is strictly preferred iff: $\delta(1-\alpha) > \frac{1}{2} > \delta\alpha$. Henceforth, this is referred to as the *sufficient ambiguity condition.*

Thus, if Player 1 satisfies the sufficient ambiguity condition, she should contribute $4ECU$ per round, in order to ensure that the threshold is reached. The equilibrium under ambiguity (EUA) for Player 2 is symmetric to that of Player 1. He should also contribute $4ECU$ per round, if he is ambiguous about the safety threshold being reached.[7]

The testable hypothesis that arises from this discussion is that though the efficient Nash equilib-

[7] We use the convention that female pronouns denote Player 1 and male pronouns denote Player 2. Of course this convention is for convenience only and bears no relation to the actual gender of subjects in the experiments.

rium predicts subjects should contribute $2ECU$ per round or $10ECU$ in total, EUA suggests that subjects who are ambiguity-averse would contribute greater than $10ECU$ in total, in order to ensure that the safety threshold is reached.

3 Experimental Design

The experiments were coded using z-Tree software (Fischbacher (2007)). A threshold public goods game is employed to model individuals' decisions to insure themselves.[8]

Four treatments were employed as under:

Treatment I - This is the base treatment, where subjects were informed: "You will be assigned to a team with one other person. Each member of the team will be given an endowment of 30ECU and will play 5 rounds as part of the same team. There is a climate change catastrophe that might occur with some unknown probability.[9] If the catastrophe occurs, both team members will lose ALL their money. You can protect your team against such a loss, if your team (the other member and yourself) decides to purchase a Climate Change Insurance Policy. In each round, each member has the choice of contributing 0 ECU, 1 ECU, 2 ECU, 3 ECU or 4 ECU from his/her endowment to a team "pot". The team insurance will only be purchased if the pot contains at least 20 ECU at the end of all 5 rounds." The base treatment was designed to analyse whether individuals were sufficiently concerned by climate change catastrophes in order to successfully insure themselves.

All subsequent treatments were variations of Treatment I as below:

Treatment II - In this treatment, subjects were informed: "In the past few periods, climate change catastrophes are known to have struck at least 80% of the time." Thus, subjects are given additional information about the probability with which catastrophes have occurred in the past. It is important to note here that the probability with which the catastrophic event takes place in the current period is an independent event, whose probability is still ambiguous. The frequency with

[8]The motivation behind using a threshold public goods game has been detailed in the introduction section.

[9]The probability with which the catastrophe would occur was unknown even to the experimenter and was determined by a random generator on z-Tree.

which a flood/storm has impacted an area, makes it *more likely* that it might happen again, but does not guarantee the event happening each period. The aim of this treatment is to check whether educating/informing subjects about the increased frequency of weather-related catastrophes leads to an increase in the insurance contributions and to check for the emergence of a "lemons" market.

Treatment III - This treatment is analogous to Bohnet *et al.* (2008), in that participants are matched against a computer in order to remove strategic uncertainty. In this treatment, subjects were informed: "You have been assigned to a team, where a computer is the other player. The computer you are teamed with, has been programmed to contribute $2ECU$/round. Do not expect it to deviate from this strategy." Thus, this treatment removes the strategic uncertainty involved in coordinating with another player and hence, strictly captures the ambiguity-averse reaction to the climate change event. It is thus possible to compare the effects of exogenous uncertainty to endogenous (strategic) uncertainty. Here, the contribution of the team-member is assured and as such, only subjects who are not ambiguity-averse about the climate event should contribute $0ECU$. If subjects are mildly concerned about the catastrophe occurring, they should contribute $10ECU$, since the computer is guaranteed to contribute the balance. In reality, this treatment maps the scenario where society expects everyone to make contributions towards a climate change catastrophe insurance (similar to national insurance contributions or mandatory motor insurance, this might be a scenario that governments consider in the future). This treatment evaluates whether it makes people contribute more willingly, if they know that their team-member is definitely contributing too. Only individuals who are not concerned about the catastrophe taking place would be reluctant to contribute in this treatment.

Treatment IV - In this treatment, subjects were informed: "The government has taken into account the grave losses that might occur as a result of a climate change catastrophe. As such, with your best interests at heart, all players are pre-assigned to a $2ECU$/round level of contribution towards the insurance. If you are unhappy with this pre-assigned contribution level, you can change your contribution, but will need to confirm this decision by answering a simple mathematics question."

This treatment was designed to simulate a government "nudge", such that subjects are automatically enrolled to a "pre-assigned" contribution level. If subjects are dissatisfied with this automatic assignment, they needed to take conscious (and concrete) steps to opt off it. As such, subjects could not opt off as a result of a "tremble". The pre-assigned contribution level, is the contribution level predicted by the efficient symmetric Nash equilibrium (also the Nash that would be consistent with fairness constraints). Similarly, subjects who wanted to deviate from the pre-assigned contribution levels to *increase* their contributions also had to perform the simple task, in order to ensure that the deviation was not a tremble/mistake, but consciously determined. This again reflects the real world, where individuals who want to make higher rate pension contributions need to be proactive in order to sign up to the higher rate.

The experimental sessions were conducted at the Finance and Economics Experimental Laboratory in Exeter (FEELE), UK between October 2015 and May 2016. A total of 719 subjects took part in the experiments, 319 of whom were male and the remaining 400 were female. The breakdown of subjects between treatments were as follows: Treatment I - 180 subjects, Treatment II - 192 subjects, Treatment III - 153 subjects and Treatment IV - 194 subjects. Each session lasted a maximum of 45 minutes including payment.

Subjects first read through a short, comprehensive set of instructions at their own pace.[10] The subjects were then asked to fill out practice questions to check that they understood the game correctly. Subjects could not proceed to the main experiment until they had correctly answered the practice questions. As such, if subjects were unable to answer a question correctly, they were assisted and their doubt/query resolved before they proceeded to take part in the main experiment. Subjects were randomly assigned to groups of two (except Treatment III, where they were paired with the computer), and remained in the same group for the rest of the experiment.

The experiment was "framed", explicitly mentioning a climate change catastrophe.[11] The provi-

[10] The experimental protocols are available in the Appedix.

[11] The experiment was framed to mention a climate change catastrophe, however, the findings would also be applicable to any other low-probability high-impact event that was not weather related.

sion threshold of $20ECU$ was common knowledge among the participants. In each round, subjects had to make a decision about how much to contribute (between $0 - 4ECU$) towards the group insurance.[12] Each subject could only select one option per round. In Treatment IV, subjects were pre-assigned to a contribution of $2ECU$ per round, and had to solve a simple mathematics question correctly in order to deviate from the pre-assigned selection. Participants were not reminded about their own previous cumulative contributions. Subjects could not communicate with each other during the experiment. Moreover, they received no information about their team member's contribution decisions between rounds - therefore, there was no opportunity to update one's beliefs.

Once subjects had made all the decisions, the result screen informed subjects about how much the group contribution towards the insurance had been and whether the insurance had been purchased. There was no reimbursement of contributions, if the threshold was not reached or if surplus contributions were made to the insurance. The computer used a random algorithm to simulate whether the climate change catastrophe had occurred (or not), and calculated the final payoff in ECU and GBP, for each subject. Subjects were paid a show-up fee of £3, together with their earnings, where $5ECU = £1$.[13] Average payoffs per treatments were as follows: Treatment I - £5.50, Treatment II - £6, Treatment III - £6.40 and Treatment IV - £5.50.[14]

4 Data Analysis and Discussion

Subjects were not dynamically consistent in their contribution choices, which forced analysis to be restricted to overall contributions only. For example one subject contributed $2ECU$, $3ECU$, $0ECU$, $1ECU$ and $4ECU$ in the five rounds respectively. It would be hard to classify this subject based on the per round contributions. As such, subjects have been classified according to their total contribution towards purchasing the insurance (See Table 1). Subjects contributing less than

[12] The experiment was planned to consist of five rounds, in order to compare the contributions made in each round to the theoretical prediction (Nash and EUA). However, subjects were not dynamically consistent in their contribution choices, which forced analysis to be restricted to overall contributions only. For example one subject contributed $2ECU$, $3ECU$, $4ECU$, $1ECU$ and $0ECU$ in the five rounds.

[13] Participants' show-up fee was not affected by the climate change catastrophe.

[14] Payoffs were rounded up to the nearest $20p$, for the purpose of payment.

$10ECU$ form Group A, subjects contributing exactly $10ECU$ (or the contribution level predicted by the efficient symmetric Nash) fall in Group B, and subjects contributing more than $10ECU$ (or those conforming with the Equilibrium under Ambiguity (EUA) prediction) fall in Group C. Only 19 (2.64%) out of the total 719 subjects that took part in the experiments contributed nothing towards buying the insurance (i.e., $0ECU$ in each round). It was found that there were only 2 (0.28%) subjects who strictly satisfied the sufficient ambiguity condition[15] and contributed $4ECU$ each round.[16]

Table 1: Individual Contribution Levels

	Group A		Group B		Group C	
	$Cont. < 10ECU$		$Cont. = 10ECU$		$Cont. > 10ECU$	
Treatment I	38	21.11%	94	52.22%	48	26.67%
Treatment II	24	12.50%	105	54.69%	63	32.81%
Treatment III	29	18.95%	97	63.40%	27	17.65%
Treatment IV	53	27.32%	96	49.48%	45	23.20%
Overall	144	20.03%	392	54.52%	183	25.45%

Observed subject behaviour in the experiments, on the whole, suggested that subjects were indeed concerned about the losses that could be caused by a climate change catastrophe. Table 2 shows the number of groups that successfully reached the required threshold and safeguarded themselves against the climate change catastrophe. Binomial tests were run to ascertain whether the number of groups reaching the threshold in each treatment was significantly more than the number of groups that failed to reach the threshold. Table 3 shows that null was rejected at a 1% significance level overall and for Treatments I, II and III, and at a 5% significance level for Treatment IV.

Table 2: Success in buying the Climate Change Insurance

	T I	*T II*	*T III*	*T IV*
No. of groups participating	90	96	153	97
No. of groups reaching threshold	60	76	124	57
No. of groups not reaching threshold	30	20	29	40
% of successful groups	66.67%	79.17%	81.05%	58.76%

[15] The sufficient ambiguity condition requires that the subjects' δ and α satisfy the condition: $\delta(1-\alpha) > \frac{1}{2} > \delta\alpha$. See Section 2.2 for more detail.

[16] Only two subjects contributed $4ECU$ per round: one played in Treatment I and the other in Treatment IV.

Table 3: Binomial Test Results

Null Hypothesis (H_0):	$prob$(threshold reached) = $prob$(threshold not reached)
Alt. Hypothesis (H_1):	$prob$(threshold reached) > $prob$(threshold not reached)
Treatment I	3.1623***
Treatment II	5.7155***
Treatment III	7.6803***
Treatment IV	1.7261**
Overall	9.4825***
*, **, *** indicate significance levels of 10%, 5% and 1% respectively.	

In Treatment I (the base treatment), two-thirds of the groups (60 groups) successfully purchased the insurance. This shows us that subjects are indeed concerned about climate change catastrophes and their impact. When given the opportunity to insure themselves, subjects tend to do so. From Table 1, it can be noted that approximately 21% of subjects (Group A) either tried to coordinate asymmetrically, or were happy to free-ride on others' contributions; 52% of subjects (Group B) attempted to coordinate in order to achieve the more efficient symmetric Nash, and 26% (Group C) made contributions that were consistent with the EUA. It is clear that a majority of subjects conform to the symmetric Nash equilibrium, however, a significant number of subjects contribute more than predicted by Nash. Another factor that could be affecting the decision of subjects that fall in Group C (in Treatment I), may be weak altruism (Wilson (1990)). As such, subjects willingly bear the burden of purchasing the insurance on their own, in order to safeguard the team as a whole.

Since there was no reimbursement of contributions, contributing both more and less than necessary to reach the threshold is inefficient. Table 4 summarises the number of groups who contributed inefficiently. It can be noted that in Treatment I, about 66.67% of groups made inefficient contributions to the purchase of the insurance.

Table 4: Efficiency Analysis

	Cont. $< 20ECU$	Cont. $> 20ECU$	Total Ineff. Groups	Total Groups	Inefficiency Rate
Treatment I	30	30	60	90	66.67%
Treatment II	20	44	64	96	66.67%
Treatment III	29	27	56	153	36.60%
Treatment IV	40	29	69	97	71.13%
Overall	119	130	249	436	57.11%

In Treatment II, subjects were provided more information regarding the frequency with which the catastrophe had occurred in the past. Subjects were found to take this additional information on board, and this resulted in an increase in the number of groups that successfully purchase the insurance to 79.17% (76 groups). A Fisher exact test[17] shows that there is a significant increase in the number of groups purchasing the insurance, when compared to the base treatment ($P = 0.069$). As such, if individuals are given more information about the frequency of climate change catastrophes, they update their beliefs and successfully insure themselves.

Thus, if individuals perceive that they might be at a high risk of being the victim of a climate change catastrophe, their insurance subscriptions would increase. However, this would lead to a "lemons" problem emerging in the climate change insurance market, such that only high-risk customers are insured. Private insurers would not be willing/able to pool risks efficiently in such a scenario. Asymmetric subscriptions may result in the need for government intervention, in order to improve the market outcome.

In terms of efficiency, Treatment II does not differ much from the base treatment (See Table 4). About 66.67% of groups made inefficient contributions, with a majority of the groups over-contributing towards the insurance.

In Treatment III, the strategic uncertainty of coordinating with another player was removed. Subjects were paired with a computer programmed to contribute $2ECU$ each round. From the data, it can be seen that 81.05% (124 subjects) successfully reached the required threshold - i.e., when strategic uncertainty was removed, the number of subjects purchasing the insurance increased. When compared to the base treatment, a Fisher exact test[18] shows that there is a significant increase in the number of subjects purchasing the insurance in Treatment III ($P = 0.014$).

Under Treatment III, if subjects are not concerned about the climate change catastrophe, they should contribute $0ECU$. The data gathered for this treatment, finds that 6 subjects contributed

[17](H_0: The proportion of groups buying insurance in $T\ I$ and $T\ II$ are identical, H_1: The proportion of groups buying insurance in $T\ I$ and $T\ II$ are not identical.)

[18](H_0: The proportion of groups buying insurance in $T\ I$ and $T\ III$ are identical, H_1: The proportion of groups buying insurance in $T\ I$ and $T\ III$ are not identical.)

$0ECU$ towards the insurance. Thus, a small minority (3.92%) of subjects did not find the catastrophe a matter of concern. In this treatment, it is inefficient to contribute both more and less than $10ECU$, since the computer is guaranteed to contribute the remaining. There were 27 subjects who contributed more than $10ECU$ and 23 subjects who made a positive contribution (i.e., greater than $0ECU$) but not enough to reach the threshold. This was the most efficient treatment overall.

Following on from Treatment II, which implied that there might be a case for government intervention in the climate change insurance market, Treatment III implies that if public policy was to move towards a situation where mandatory climate change insurance was required, i.e., individuals were all required to contribute towards a nation-wide climate change catastrophe "reserve", a large majority of people would be happy to contribute to the reserve/insurance, provided others' contributions were guaranteed as well. This scenario would be similar to the current requirement for everyone to possess motor insurance, and make National Insurance contributions in the UK.

Treatment IV simulated a government "nudge" where subjects are automatically enrolled to a "pre-assigned" contribution level, but could opt off it. The pre-assigned contribution level was the contribution level was $2ECU$ (the efficient symmetric Nash contribution, that would also be consistent with fairness constraints). It was found that the number of groups successfully purchasing the insurance (58.76% or 57 groups) was lower than in the base treatment.

It is very interesting to note that Government intervention or the "nudge" seems to have backfired - i.e., subjects exerted an effort to opt off the pre-assigned contribution level. A Fisher exact test[19] finds no difference between Treatments I and IV ($P = 0.292$), reflecting that the "nudge" was not successful in affecting people's behaviour or that it may have even caused a "rebellious" behaviour on the part of subjects. This is termed as a "*boomerang effect*" in psychology, where an attempt to persuade a subject, results in the unintended consequence of him adopting an opposing position instead. The boomerang effect phenomenon was first identified by Brehm & Brehm (1981) and has since been documented in other studies considering individual behaviour in socio-economic situations

[19](H_0: The proportion of groups buying insurance in $T\ I$ and $T\ IV$ are identical, H_1: The proportion of groups buying insurance in $T\ I$ and $T\ IV$ are not identical.)

(See Werch *et al.* (2000), Wechsler *et al.* (2003), Perkins *et al.* (2005), Schultz *et al.* (2007), Allcott (2011)).

In the current study, 53 (27%) subjects exerted the extra effort required to reduce their contribution level. Interestingly, 45 (23%) subjects exerted the extra effort required in order to *increase* their contribution levels. These subjects display that they are willing to contribute *more* than the standard State-required contribution level in order to avoid ambiguous losses. About 50% of the subjects (96 subjects) remained at the "State-determined" pre-assigned contribution level. In terms of efficiency, Treatment IV was the most inefficient treatment (See Table 4). About 71.13% of groups made inefficient contributions, with a bulk of the groups under-contributing towards the insurance.

The standard Ellsberg (1961) urn question was posed to subjects, in order to determine their ambiguity-attitude. For an extensive survey of the literature on Ellsberg experiments, see Trautmann & van de Kuilen (2016). In the current study, the Ellsberg urn question posed to the subjects was not incentivised. For other papers that also assume that non-incentivised Ellsberg-style thought experiments reveal true preferences see Butler *et al.* (2014) and Bianchi & Tallon (2016). Cavatorta & Schröder (2016) conduct a comprehensive study that provides empirical support to the assumption that unincetivised thought experiments are significantly correlated to ambiguity preferences that are obtained in incentivised decision tasks.

The question posed to the subjects was: "An urn contains 90 balls, of which 30 are labelled X. The remainder are labelled either Y or Z. Which of the following options do you prefer? A payoff of 100 if a ball labelled X is drawn or a payoff of 100 if a ball labelled Y is drawn." Ambiguity-averse subjects should choose to bet on balls labelled X, as their quantity is known. Ambiguity-seeking subjects would be expected to choose to bet on balls labelled Y, whose quantity is unknown.

Dummy variables were defined for the various treatments (Treatment I, Treatment II, etc.) and to capture subjects' ambiguity-attitude (Ambiguity-Averse/Ambiguity-Seeking). A probit regression was run to ascertain what factors increased the likelihood of the insurance being bought. Table 5 provides the results of a probit regression of "*Bought*" on the various treatment and ambiguity-attitude dummies. The dummy for Treatment I and ambiguity-seeking attitude were dropped from the probit regression, in order to avoid the problem of collinearity. Dummies for degree/subject studied at university of subjects, age and gender were found to be insignificant, and were thus dropped from the final regression.[20] The final regression has a chi-square ratio of 36.55 with a p-value of 0.0000, which indicates that our model as a whole is statistically significant.

Table 5: Probit Regression Results

Variable	Coefficient	Std. Err.	z	$P > \|z\|$	[95% Conf. Interval]	
Treatment II	.3794556***	.1412632	2.69	0.007	.1025848	.6563264
Treatment III	.4310939***	.1526451	2.82	0.005	.1319151	.7302728
Treatment IV	−.2192589*	.1330922	−1.65	0.099	−.4801149	.0415971
Ambiguity Averse	.2946323***	.1113287	2.65	0.008	.076432	.5128325
Constant	.2259345*	.1239068	1.82	0.068	−.0169183	.4687873
*, **, *** indicate significance levels of 10%, 5% and 1% respectively.						

The coefficients from a probit regression do not have the same interpretation as coefficients from an Ordinary Least Squares regression. From Table 5, we can interpret that in Treatment II the z-score increases by 0.38, making it more likely for the insurance to be bought than in the base treatment. Similarly in Treatment III, the z-score increases by 0.43, but in Treatment IV the z-score decreases by 0.219, compared to the base treatment. Treatment IV was only significant at 10% while Treatments II and III were significant at 1%. It can be concluded that Treatments II and III provide situations where the insurance is more likely to be purchased, while Treatment IV hampers contributions. Moreover if a subject is ambiguity-averse in the classic Ellsberg urn situation, the z-score increases by 0.29, making it significantly more likely for the insurance to be purchased than the reference group (ambiguity-seeking people). This is in line with the hypothesis that ambiguity-aversion would make individuals more likely to contribute towards a climate change insurance.

[20] This information is collected as standard practice for all subjects who take part in experiments at FEELE.

5 Conclusion

Overall, subjects' behaviour was consistent with Nash equilibrium, however, a sizable minority of subjects did display behaviour consistent with an ambiguity-averse attitude. It is important to note that it is easier to coordinate on the Nash equilibrium, when the group consists of two people. Increasing the group size beyond two, might result in an increase in coordination failures and/or increase in contributions fuelled by ambiguity-averse behaviour (since strategic ambiguity can be seen to increase with group-size).

A majority of subjects do reach the threshold required to insure themselves against the climate change catastrophe. This indicates that individuals are concerned about climate change and the resultant impact it may have on our every day lives. As such, there may be scope for insurance companies to offer insurances tailored specifically to cover climate-change related catastrophes, with premiums that reflect the low frequency/high-impact nature of climate events, which have a long tail in terms of liabilities.

An insurance of this type would require a widespread up-take, in order to sufficiently cross-insure risks across geographical regions and make it feasible from the insurance companies' point of view. Increasing the availability of information about the impact/frequency of climate change catastrophes in the past (Treatment II), leads to a significant increase in insurance subscriptions amongst those individuals who perceive themselves to be at a high-risk of becoming victims. Unless individuals perceived to live in "high-risk" areas, are cross-insured by individuals living in "low-risk" areas, insurance companies would find that all their customers were "lemons" and would quickly go out of business.

Government intervention may thus be required in order to improve the market outcome in the presence of asymmetric subscriptions. Treatment III finds that removing the strategic uncertainty of contribution towards the insurance results in a significant increase in insurance subscriptions. Thus, if public policy moved towards a situation where mandatory climate change insurance was required, a large majority of people would be happy to contribute to a climate change insurance, provided others' contributions were guaranteed as well. Interestingly, an indirect State intervention in the form of a "nudge" does not have the intended effects. The nudge was in fact found to be counter-productive and may have resulted in a fall in subscriptions. In terms of efficiency, again, removing the strategic uncertainty of others' contributions (Treatment III) provides the best results.

In future investigations, it might be interesting to ascertain whether subjects who failed to reach the threshold and lost their endowment as a result of the catastrophe "occurring", behave differently if they are asked to play the game again. This would be an extension of Treatment II, since subjects will have experienced first-hand the damage caused by failing to secure the insurance. In reality, insurance premiums would increase to reflect the growing frequency of the catastrophe. As such, it would be interesting to see whether subjects are willing to pay *more* to buy an insurance, which they had failed to purchase previously at a lower price. The key idea here is to investigate whether experiencing a low-probability high-impact event can change the ambiguity-attitude of a subject.

Climate change and its allied effects are becoming inevitable, and as such, greater measures need to be put in place to safeguard individuals' interests. In this study, indirect state interventions or nudges, were found to be ineffective in the climate change context. As such, further investigations may be needed to ascertain more direct mechanisms that would ensure a better outcome.

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A Appendix

A.1 Treatment I - Experiment Instructions

(Instructions Screen)

You are participating in an experiment on decision-making. If you follow the instructions and apply them carefully, you can earn some money in addition to the 3.00 pound show-up fee which we will give you in any case. From now on you are not allowed to talk to any other participants in the experiment. If you have a question, please raise your hand and one of the instructors will attend to you.

(Instructions Screen)

You will be assigned to a team with one other person. Each member of the team will be given an endowment of 30ECU and will play 5 rounds as part of the same team.

There is a climate change catastrophe that might occur with some unknown probability.

If the catastrophe occurs, both team members will lose ALL their money. You can protect your team against such a loss, if your team (the other member and yourself) decides to purchase a **Climate Change Insurance Policy**.

The experiment will consist of **5 rounds**. In each round, each member has the choice of contributing 0 ECU, 1 ECU, 2 ECU, 3 ECU or 4 ECU from his/her endowment to a team "pot".

The team insurance will only be purchased if the pot contains **at least 20 ECU** at the end of all 5 rounds.

If the Insurance is purchased at the end of the 5 rounds, then each member's payoff will simply be 30 ECU minus his/her total contributions to the pot.

If the Insurance is NOT purchased at the end of the 5 rounds, then each member's payoff will depend on the occurrence of the Climate Change Catastrophe.

(a) If the Catastrophe occurs: Each member's payoff will be 0 ECU.

(b) If the Catastrophe does not occur: Each member's payoff will be 30 ECU minus his/her total contributions to the pot.

At the end of the experiment your experimental money (ECU) will be converted into cash at the exchange rate of 5 ECU for 1 Pound.

Click the "Next" button to start a simple test that examines your understanding of the experimental design.

(Questionnaire Screen)

Here are some questions to ensure your understanding of the experimental design.

(Q1). Suppose the team contributes 22 ECU to the Pot. The climate change insurance is:

(Radio Button) Bought

(Radio Button) Not Bought

(Q2). Suppose the team contributes 18 ECU to the Pot. The climate change insurance is:

(Radio Button) Bought

(Radio Button) Not Bought

(Q3) Suppose you contributed 3 ECU at each round and the total amount in the pot is 25 ECU. The insurance is bought. A climate change catastrophe occurs. Your experiment Payoff is (ECU):

(Field to be filled in by subject)

(Q4) Suppose you contributed 1 ECU at each round and the total amount in the pot is 15 ECU. The insurance is NOT bought. A climate change catastrophe occurs. Your experiment Payoff is (ECU):

(Field to be filled in by subject)

(Q5) Suppose you contributed 1 ECU at each round and the total amount in the pot is 15 ECU. The insurance is NOT bought. A climate change catastrophe did not occur. Your experiment Payoff is (ECU):

(Field to be filled in by subject)

Click the "Submit" button only when you have decided on your answers. The experiment will start once everyone has completed the instructions.}

(Summary Screen)

You have been granted an endowment of 30 ECU, and are part of a team consisting of one other member.

You are warned that a climate change catastrophe may occur with some unknown probability, causing you to lose your endowment.

(Start button that begins the experiment)

A.2 Treatment II - Experiment Instructions

(Instructions Screen)

You are participating in an experiment on decision-making. If you follow the instructions and apply them carefully, you can earn some money in addition to the 3.00 pound show-up fee which we will give you in any case. From now on you are not allowed to talk to any other participants in the experiment. If you have a question, please raise your hand and one of the instructors will attend to you.

(Instructions Screen)

You will be assigned to a team with one other person. Each member of the team will be given an endowment of 30ECU and will play 5 rounds as part of the same team.

There is a climate change catastrophe that might occur with some unknown probability.

If the catastrophe occurs, both team members will lose ALL their money. You can protect your team against such a loss, if your team (the other member and yourself) decides to purchase a **Climate Change Insurance Policy**.

In the past few periods, climate change catastrophes are known to have struck at least 80% of the time.

The experiment will consist of **5 rounds**. In each round, each member has the choice of contributing 0 ECU, 1 ECU, 2 ECU, 3 ECU or 4 ECU from his/her endowment to a team "pot".

The team insurance will only be purchased if the pot contains **at least 20 ECU** at the end of all 5 rounds.

If the Insurance is purchased at the end of the 5 rounds, then each member's payoff will simply be 30 ECU minus his/her total contributions to the pot.

If the Insurance is NOT purchased at the end of the 5 rounds, then each member's payoff will depend on the occurrence of the Climate Change Catastrophe.

(a) If the Catastrophe occurs: Each member's payoff will be 0 ECU.

(b) If the Catastrophe does not occur: Each member's payoff will be 30 ECU minus his/her total contributions to the pot.

At the end of the experiment your experimental money (ECU) will be converted into cash at the exchange rate of 5 ECU for 1 Pound.

Click the "Next" button to start a simple test that examines your understanding of the experimental design.

(Questionnaire Screen)

Here are some questions to ensure your understanding of the experimental design.

(Q1). Suppose the team contributes 22 ECU to the Pot. The climate change insurance is:

(Radio Button) Bought

(Radio Button) Not Bought

(Q2). Suppose the team contributes 18 ECU to the Pot. The climate change insurance is:

(Radio Button) Bought

(Radio Button) Not Bought

(Q3) Suppose you contributed 3 ECU at each round and the total amount in the pot is 25 ECU. The insurance is bought. A climate change catastrophe occurs. Your experiment Payoff is (ECU):

(Field to be filled in by subject)

(Q4) Suppose you contributed 1 ECU at each round and the total amount in the pot is 15 ECU. The insurance is NOT bought. A climate change catastrophe occurs. Your experiment Payoff is (ECU):

(Field to be filled in by subject)

(Q5) Suppose you contributed 1 ECU at each round and the total amount in the pot is 15 ECU. The insurance is NOT bought. A climate change catastrophe did not occur. Your experiment Payoff is (ECU):

(Field to be filled in by subject)

Click the "Submit" button only when you have decided on your answers. The experiment will start once everyone has completed the instructions.}

(Summary Screen)

You have been granted an endowment of 30 ECU, and are part of a team consisting of one other member.

You are warned that a climate change catastrophe may occur with some unknown probability, causing you to lose your endowment.

In the past few periods, climate change catastrophes are known to have struck at least 80% of the time.

(Start button that begins the experiment)

A.3 Treatment III - Experiment Instructions

(Instructions Screen)

You are participating in an experiment on decision-making. If you follow the instructions and apply them carefully, you can earn some money in addition to the 3.00 pound show-up fee which we will give you in any case. From now on you are not allowed to talk to any other participants in the experiment. If you have a question, please raise your hand and one of the instructors will attend to you.

(Instructions Screen)

You will be assigned to a team with one other person. Each member of the team will be given an endowment of 30ECU and will play 5 rounds as part of the same team.

There is a climate change catastrophe that might occur with some unknown probability.

If the catastrophe occurs, both team members will lose ALL their money. You can protect your team against such a loss, if your team (the other member and yourself) decides to purchase a **Climate Change Insurance Policy**.

The experiment will consist of **5 rounds**. In each round, each member has the choice of contributing 0 ECU, 1 ECU, 2 ECU, 3 ECU or 4 ECU from his/her endowment to a team "pot".

The team insurance will only be purchased if the pot contains **at least 20 ECU** at the end of all 5 rounds.

You have been assigned to a team, where a computer is the other member.

The computer you are teamed with, has been programmed to contribute 2 ECU at each round.

Do not expect it to deviate from this strategy.

If the Insurance is purchased at the end of the 5 rounds, then each member's payoff will simply be 30 ECU minus his/her total contributions to the pot.

If the Insurance is NOT purchased at the end of the 5 rounds, then each member's payoff will depend on the occurrence of the Climate Change Catastrophe.

(a) If the Catastrophe occurs: Each member's payoff will be 0 ECU.

(b) If the Catastrophe does not occur: Each member's payoff will be 30 ECU minus his/her total contributions to the pot.

At the end of the experiment your experimental money (ECU) will be converted into cash at the exchange rate of 5 ECU for 1 Pound.

Click the "Next" button to start a simple test that examines your understanding of the experimental design.

(Questionnaire Screen)

Here are some questions to ensure your understanding of the experimental design.

(Q1). Suppose the team contributes 22 ECU to the Pot. The climate change insurance is:

(Radio Button) Bought

(Radio Button) Not Bought

(Q2). Suppose the team contributes 18 ECU to the Pot. The climate change insurance is:

(Radio Button) Bought

(Radio Button) Not Bought

(Q3) Suppose you contributed 3 ECU at each round and the total amount in the pot is 25 ECU. The insurance is bought. A climate change catastrophe occurs. Your experiment Payoff is (ECU):

(Field to be filled in by subject)

(Q4) Suppose you contributed 1 ECU at each round and the total amount in the pot is 15 ECU. The insurance is NOT bought. A climate change catastrophe occurs. Your experiment Payoff is (ECU):

(Field to be filled in by subject)

(Q5) Suppose you contributed 1 ECU at each round and the total amount in the pot is 15 ECU. The insurance is NOT bought. A climate change catastrophe did not occur. Your experiment Payoff is (ECU):

(Field to be filled in by subject)

Click the "Submit" button only when you have decided on your answers. The experiment will start once everyone has completed the instructions.}

(Summary Screen)

You have been granted an endowment of 30 ECU, and are part of a team consisting of one other member (a Computer).

You are warned that a climate change catastrophe may occur with some unknown probability, causing you to lose your endowment.

(Start button that begins the experiment)

A.4 Treatment IV - Experiment Instructions

(Instructions Screen)

You are participating in an experiment on decision-making. If you follow the instructions and apply them carefully, you can earn some money in addition to the 3.00 pound show-up fee which we will give you in any case. From now on you are not allowed to talk to any other participants in the experiment. If you have a question, please raise your hand and one of the instructors will attend to you.

(Instructions Screen)

You will be assigned to a team with one other person. Each member of the team will be given an endowment of 30ECU and will play 5 rounds as part of the same team.

There is a climate change catastrophe that might occur with some unknown probability.

If the catastrophe occurs, both team members will lose ALL their money. You can protect your team against such a loss, if your team (the other member and yourself) decides to purchase a **Climate Change Insurance Policy**.

The experiment will consist of **5 rounds**. In each round, each member has the choice of contributing 0 ECU, 1 ECU, 2 ECU, 3 ECU or 4 ECU from his/her endowment to a team "pot".

The government has taken into account the grave losses that might occur as a result of a climate change catastrophe. As such, with your best interests at heart, all players are pre-assigned to a 2ECU/round level of contribution towards the insurance. If you are unhappy with this pre-assigned contribution level, you can change your contribution, but will need to confirm this decision by answering a simple math question.

The team insurance will only be purchased if the pot contains **at least 20 ECU** at the end of all 5 rounds.

If the Insurance is purchased at the end of the 5 rounds, then each member's payoff will simply be 30 ECU minus his/her total contributions to the pot.

If the Insurance is NOT purchased at the end of the 5 rounds, then each member's payoff will depend on the occurrence of the Climate Change Catastrophe.

(a) If the Catastrophe occurs: Each member's payoff will be 0 ECU.

(b) If the Catastrophe does not occur: Each member's payoff will be 30 ECU minus his/her total contributions to the pot.

At the end of the experiment your experimental money (ECU) will be converted into cash at the exchange rate of 5 ECU for 1 Pound.

Click the "Next" button to start a simple test that examines your understanding of the experimental design.

(Questionnaire Screen)

Here are some questions to ensure your understanding of the experimental design.

(Q1). Suppose the team contributes 22 ECU to the Pot. The climate change insurance is:

(Radio Button) Bought

(Radio Button) Not Bought

(Q2). Suppose the team contributes 18 ECU to the Pot. The climate change insurance is:

(Radio Button) Bought

(Radio Button) Not Bought

(Q3) Suppose you contributed 3 ECU at each round and the total amount in the pot is 25 ECU. The insurance is bought. A climate change catastrophe occurs. Your experiment Payoff is (ECU):

(Field to be filled in by subject)

(Q4) Suppose you contributed 1 ECU at each round and the total amount in the pot is 15 ECU. The insurance is NOT bought. A climate change catastrophe occurs. Your experiment Payoff is (ECU):

(Field to be filled in by subject)

(Q5) Suppose you contributed 1 ECU at each round and the total amount in the pot is 15 ECU. The insurance is NOT bought. A climate change catastrophe did not occur. Your experiment Payoff is (ECU):

(Field to be filled in by subject)

Click the "Submit" button only when you have decided on your answers. The experiment will start once everyone has completed the instructions.}

(Summary Screen)

You have been granted an endowment of 30 ECU, and are part of a team consisting of one other member.

You are warned that a climate change catastrophe may occur with some unknown probability, causing you to lose your endowment.

The government has taken into account the grave losses that might occur as a result of a climate change catastrophe. As such, with your best interests at heart, all players are pre-assigned to a 2ECU/round level of contribution towards the insurance. If you are unhappy with this pre-assigned contribution level, you can change your contribution, but will need to confirm this decision by answering a simple maths question.

(Start button that begins the experiment)