

# THE ANNOUNCEMENT EFFECT & CLIMATE THRESHOLDS: EARLY WARNINGS OF FUTURE THRESHOLDS UNDER DIFFERENT FRAMING AND RISK CONTEXTS

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## *Abstract*

*The effect of announcing future institutional change is investigated in three different contexts: a gains frame, a loss frame, and a loss frame with risk. The institutional change considered here is the transition from a normal public goods game into a threshold public goods game framed in the context of dangerous climate change. Announcements may change subject behaviour, through influencing their expectations, before the implementation of the new institution (adjustment effect) and/or after the implementation (adaptation effect). We find that announcements in the Gains Treatment cause zero adjustment effects and negative adaptation effects. Announcements in the Loss Treatment cause significant positive adjustment and adaptation effects. Including risk into the threshold phase of the Loss-and-Risk Treatment causes the announcements to have zero effects. These results have important implications for early warnings and accurate forecasts related to climate change. .*

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## 1. Introduction

Humanity has, up until now, been freely contributing to the pollution of the atmosphere while the negative effects have only been felt marginally by the whole planet. However, in recent years, scientists have become aware that the climate may be reaching a tipping point due to anthropocentric interference, passed which irreversible and dangerous climate change will occur causing large, discontinuous harm to both natural and human systems (O'Neill & Oppenheimer 2002; Alley et al. 2005; Solomon et al. 2009). The 2009 Copenhagen Accord resulted in a non-binding agreement to stop catastrophic climate change by limiting the global temperature rise to below the threshold of two degrees Celsius by requiring all nations to reduce their emissions of greenhouse gasses (Rogelj et al. 2010; Anderson & Bows 2011). The scientific findings of future climate thresholds are effectively announcements of a coming change in the implicit institutional environment of carbon emissions from a continuous public good game to that of a threshold public good game. The current paper situates itself within the framework of such institutional change. Our main aim is to investigate what impact an early-warning announcement of future institutional change, such as impending climate thresholds, has on countries' voluntary contributions to carbon emissions abatement in Gains, Loss and Risky framed contexts.

This is done by building on the work done by Visser et al. (2014) by performing laboratory experiments testing the impact of announcements of future institutional change in three differently framed contexts. The institutional change is that of 20 periods of continuous public goods (PG) games transitioning into 10 periods of a threshold public goods (TPG) game. PG games have long been the experimental method for economists to study the dynamics of cooperation in social dilemmas and findings have shown that people do not act only out of narrow self-interest and do indeed perform costly cooperation (Andreoni 1995; Ledyard 1995; Hoffman et al. 1998; Zelmer 2003). The effects of making announcements of the future institutional change from the 11<sup>th</sup> period until the 20<sup>th</sup> period are tested a) in a Gains Frame, where contributions go towards yielding benefit; b) in a Loss Frame, where contributions go towards reducing a loss; and c) in a Loss-and-Risk Frame, where the negative impact from not reaching the threshold only exists with a 50% chance in the new threshold institution. The announcement effect is tested under different contexts due to the widely observed phenomenon known as framing effects, whereby peoples' behaviour systematically differs when shown

different presentational formats of logically equivalent option (Tversky & Kahneman 1986; Krishnamurthy et al. 2001; Cox 2014).

The Loss Framed context of the experimental design is particularly analogous to climate change by representing twenty periods in which countries voluntarily contribute to emissions abatement that marginally reduces the loss faced by all countries due to negative climate change. The transition into the threshold phase then represents a situation where it is found that in ten periods total emissions abatement must exceed a critical level or else a dangerous climate tipping point will be surpassed causing massive, discontinuous damage to all countries. The threshold institution mirrors the incentives for countries to avoid a dangerous climate tipping point, as it incorporates the necessity of coordination and also the temptation to free ride on others' abatement (Cadsby & Maynes 1999; Barrett & Dannenberg 2012).

A natural application of this research is the efficacy of early warning systems in the climate change debate. An integral part of early warning systems is the dissemination of timely information in order to enable threatened individuals to prepare and act so as to reduce the possibility of harm (UNISDR 2010). This information dissemination can be seen as a series of announcements, such as those described in the current paper. Numerous studies have attested to the possibility and the benefits of early warning systems with regards to the negative impacts of tipping over dangerous climate thresholds, in particular the two degree Celsius warming threshold (Lenton 2011; Rogers & Tsirkunov 2011; Huntingford et al. 2012; Marvin et al. 2013; Ludescher et al. 2014). Alfieri et al. (2012) attribute a large degree of the benefits of early warning systems to increased population preparedness and coordination, as well as a necessary philosophical perspective change from post-disaster recovery to disaster prevention. However, what is lacking from the literature is a focus on how early warning initiatives can actually affect individual-level cooperative decisions; it has even been stated that 'the individual's willingness to act cannot be taken for granted' (Rogers & Tsirkunov 2011: 14). The current study is an initial probe into this void in the literature. The inclusion of a context in our experimental design that incorporates risk in the new institution is to mimic the inherently unpredictable nature of the future and, in particular, the various uncertainties implicit with the current scientific knowledge of climate thresholds (Hallegatte 2009; Dannenberg et al. 2011; Lenton 2011; Tavoni et al. 2011; Barrett & Dannenberg 2012).

The theory of change that accounts for the potential impacts of announcements on behaviour follows closely the theory of rational expectations. The theory states that anticipation of policy change is a vital part of whether the change has an effect, as a population who anticipates change can revise their expectations, and thus their behaviour, immediately leading to zero overall policy effectiveness (Sargent & Wallace 1976; Holland 1985; Heijdra & van der Ploeg 2002). Therefore the main vehicle for behavioural change caused by announcements is their influence on the expectations of the population. In this paper we will look at two major avenues in which the announcement effect can occur. The announcements of a future institutional change can have an immediate effect, before the implementation of the new institution (*adjustment effect*) or it can have a later effect, after the implementation of the new institution (*adaptation effect*). The term *adjustment effect* has been adapted from the use of the term adjustment path which represents the effect of announcements on behaviour before the implementation of institutional change (Adams et al. 2001; Heijdra and van der Ploeg, 2002). While our *adaptation effect* term has been modified from Blundell et al.'s (2001) use of the term implementation effect to model the effect announcements have after the implementation of an institutional change.

Very little attention has been given to the impact of announcements of impending institutional change on peoples' behaviour. The financial markets literature is the most versed on such announcement effects, showing that central bank announcements alone can induce quick and widespread reactions (Urich & Wachtel 1981; Cornell 1983; Demiralp & Jordá 2001; Rosa & Verga 2008). A recent study by Visser et al. (2014) was the first to explicitly study the announcement effect of a transition to a peer punishment institution. The authors found that announcements cause no adjustment effect, but cause a double adaptation effect: increased numbers of contributors partly mediated by increased use of the punishment institution. Conversely, the effectiveness of public-messaging announcements under different framing contexts has been studied extensively, especially in the health-care sector, yet with inconclusive findings (Meyerowitz & Chaiken 1987; Rothman et al. 1993; Rothman & Salovey 1997; Edwards et al. 2010; Garcia-Retamero & Cokely 2013; Gong et al. 2013; Wong et al. 2013). The novelty of the current paper arises from being the first study to combine these two areas of research: framing effects on announcements of future institutional change. This investigation on the differential effectiveness of announcements of an impending regime shift under different

framing and risk environments therefore provides a unique contribution to the field of organisational and institutional change management.

Our findings suggest that announcements can increase the effectiveness of eventual institutional change. While in the gains frame we see zero adjustment effects and negative adaptation effects of announcements, in the loss frame we find significant positive adjustment effects of increased contributions and significant positive adaptation effects of higher likelihoods of groups reaching the threshold. However, when the loss frame is combined with risky impact from not reaching the threshold, all significant effects previously found due to announcements are negated.

We also find strong evidence that the adjustment effect in the loss frame is mediated by the announcements' influence on the likelihood of subjects playing by certain strategies such as free-riding or full cooperation. However, the evidence that the adaptation effects found in the gains and loss frames are driven by the same announcement effect on players' strategy choices is not as strong. There is also evidence that among groups successful in reaching the threshold, the announcements cause stronger, earlier action relative to successful groups who do not receive the announcements.

In the context of climate change, our results show that loss-framed, early-warnings of future climate thresholds can increase current cooperation and the signalling of cooperative intent, while also increasing the probability of avoiding dangerous climate thresholds once the institutional landscape has changed. However, less optimistic is the diluting effect of risk. It seems that if people are not convinced of the certainty of disaster resulting from exceeding a temperature threshold, then announcements will have no impact. This observation emphasises the importance of accurate climate modelling so that the uncertainty of early-warning forecasts can be reduced.

The paper will continue with section 2 giving a description of the methodology used for the experiments. After this, section 3 will provide an analysis of the main results found and discuss the implications of the results, particularly with regards to the climate change problem. Section 4 will conclude.

## **2. Methodology**

### **2.1 Subjects and Design**

309 students from the University of Cape Town (UCT) participated in the study over one week from in October 2014. Subjects were seated at computer terminals using Z-tree Software (Fischbacher 2007) and randomly split into groups of 3 without knowing the identity of their other group members. Before the experiment began, subjects were given a show-up fee of R10 and after the experiment they were asked to complete a short demographic questionnaire<sup>3</sup>. Subjects earned on average R126.48.

Subjects engaged in two experiments during the session. Initially they participated in a simple 2 choice risk experiment, following the 50/50 gamble-choice methodology of Eckel & Grossman (2008b) (Appendix A illustrates and explains the design of the gamble choice tasks). After this, subjects participated in a repeated public goods game for 30 periods, involving a “regime change” from a voluntary contribution mechanism Public Goods (PG) game, to a Threshold Public Goods (TPG) game from round 21-30. We further used a 3x2 between-subject design (shown in Table 1) whereby subjects were allocated into one of six possible treatments whilst

**Table 1 3x2 Between-Subject Design**

	Gains Frame		Loss Frame			
	Certain Impact		Certain Impact		Risky Impact	
	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6
	GCN ( <i>N</i> =45)	GCA ( <i>N</i> =48)	LCN ( <i>N</i> =51)	LCA ( <i>N</i> =54)	LRN ( <i>N</i> =54)	LRA ( <i>N</i> =57)
<b>Part 1</b>						
Periods 1-10	PG phase	PG phase	PG phase	PG phase	PG phase	PG phase
<b>Part 2</b>						
Periods 11-20	PG phase	PG phase + A	PG phase	PG phase + A	PG phase	PG phase + A
<b>Part 3</b>						
Periods 21-30	TPG phase	TPG phase	TPG phase	TPG phase	TPG phase + Risky Impact	TPG phase + Risky Impact

\* A – represents announcements before every round informing subjects about the coming change of game structure in period 21 to a TPG game

<sup>3</sup> Questionnaire available upon request from the authors

playing the public goods game. Treatments 1 & 2 were framed in terms of gains, treatments 3 & 4 were framed in terms of losses and treatments 5 & 6 were framed in terms of Loss with a risk of impact from not reaching the threshold during the final 10 rounds. In each of Treatments 2, 4 & 6 an announcement was made in each of round 11-20 to warn players of the regime change that was to happen after round 20, whereas for Treatment 1,3 and 6 no announcements were made.

### 2.1.1 PG phase: Gains and Loss Frames

In the gains framed PG game each group member ( $n=3$ ) receives an endowment ( $E$ ) of 20 tokens each period and must then decide how much to allocate to a private account ( $x_i$ ) yielding a return of 1 and how much to allocate to a group account ( $g_i$ ) ( $x_i + g_i = 20$ ), which yields a marginal per capita return (MPCR) of 0.5 for oneself and each other group member. A similar method of instructions<sup>4</sup> as Cox (2014) was used, in which it is explained that the group account starts off with zero tokens each period, and each token allocated to the group account will be multiplied by 1.5 and then split equally among all three group members. At the end of each period in the gains framed PG game, the payoff for an individual is represented by:

$$\pi_i = (E - g_i) + \frac{1.5 \times \sum_j^3 g_j}{3} \quad (1)$$

Similarly we explained the loss framed PG game to subjects by saying that the group account starts off with a 90 token deficit, and each token contributed to the group account is multiplied by 1.5 and then subtracted from the deficit. Any deficit remaining in the group account at the end of the period must then be paid for equally out of each group member's remaining private account. For this frame each group member ( $n=3$ ) receives an extra 30 tokens of non-usable endowment each period, to ensure logical equivalence to the gains frame and to mimic an already endowed, untradeable benefit deriving from a public good such as clean air to breathe or a climate that can support life. Subjects must still allocate their 20 tokens of usable endowment ( $E$ ) between a private ( $x_i$ ) and a group account ( $g_i$ ). At the end of each period in the loss framed PG game, the payoff for an individual is represented by:

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<sup>4</sup> Instructions available upon request from the Authors

$$\pi_i = 30 + (E - g_i) + \frac{((1.5 \times \sum_j^3 g_j) - 90)}{3} \quad (2)$$

Investing into the group account ( $g_i$ ) reduces the loss faced by the group by 0.5, while allocating tokens to the private account yields a positive return of 1 for oneself only. It is important to note that while the payoffs are logically equivalent, decisions in the loss frame involve actual losses from the initial endowment level, whereas decisions in the gains frame involve actual gains. This entails that the psychological phenomena associated with the identical payoffs may be different across the two frames.

This phase of the experiment mimics closely the incentives faced by individual countries in the social dilemma of climate change. Countries can either voluntarily contribute to carbon emissions reductions or they can contribute to some other private project. The value from total contributions to emissions abatement is shared equally amongst all nations, regardless of their own contributions, because the climate is a public good: an inhabitable climate is non-excludable and non-rival. The differential framing is analogous to changing the focus of the value of contributions to carbon emissions abatement. In a gains frame one can highlight the actual benefits of emissions abatement that accrue to countries compared to the current state of the climate. Whereas a loss frame can emphasise the reduction of damage faced by countries compared to some ideal state of the climate, due to lower levels of atmospheric carbon.

### 2.1.2 TPG phase: Gains and Loss Frames

Thresholds are cumulative in nature; the sum of total contributions to the public good needs to be at or above the threshold level by the end of the 30<sup>th</sup> period to avoid loss or gain a reward (for example: Milinski et al. 2008; Dannenberg et al. 2011; Tavoni et al. 2011). We utilise a high threshold level of 75% of total contributable group endowment ( $T=450$ ) and the reward (loss) for reaching (not reaching) the threshold ( $v$ ) is set at 300 tokens for each group member. We do not use any refund or rebate rules, so cumulative contributions below or above the threshold level are wasted.

The design of the threshold phase reproduces the situation that countries face when scientific findings report that a dangerous climate tipping point will be surpassed and cause mass damage ( $v$ ) if total reductions in carbon emissions do not reach a critical level ( $T$ ) in a number of years



(e.g 10 years). The idea that contributions accumulate represents the fact that contributions to emissions abatement will have to continue for a number of years in order to reduce the levels of atmospheric carbon so as to avoid a dangerous climate tipping point (Alley et al. 2005; Keller et al. 2004). Additionally, the use of a high threshold level simulates the large degree of cooperation that it will take to avoid the climate threshold, while the lack of refund or rebate rules reproduces the sunk-cost nature of investments into carbon emissions reductions.

The gains frame rewards ( $v$ ) groups whose total contributions are greater than or equal to the threshold level after the 10 periods of the TPG game. Each period, every group member ( $n=3$ ) receives an endowment ( $E$ ) of 20 tokens and must decide how much to allocate to a private account ( $x_i$ ) and how much to a joint account ( $g_i$ ). At the end of the 10 periods of the gains-framed TPG game, the payoff for an individual is shown by:

$$\pi_i = \sum_{t=21}^{30} E_{it} - \sum_{t=21}^{30} g_{it} + v, \quad \text{if } \sum_{t=21}^{30} g_{1t} + g_{2t} + g_{3t} \geq T \quad (3)$$

$$\pi_i = \sum_{t=21}^{30} E_{it} - \sum_{t=21}^{30} g_{it}, \quad \text{if } \sum_{t=21}^{30} g_{1t} + g_{2t} + g_{3t} < T \quad (4)$$

The loss framed TPG game works in a similar way to the loss framed PG game in that subjects receive an extra, non-usable 30 tokens each period and a usable endowment ( $E$ ) of 20 tokens that are investable into either  $x_i$  or  $g_i$ . However, in the loss-frame, it is the groups who do not reach the threshold after 10 periods that incur a loss ( $-v$ ). The payoff for an individual in the loss-framed TPG game after 10 periods is as follows:

$$\pi_i = \sum_{t=21}^{30} 30 + \sum_{t=21}^{30} E_{it} - \sum_{t=21}^{30} g_{it}, \quad \text{if } \sum_{t=21}^{30} g_{1t} + g_{2t} + g_{3t} \geq T \quad (5)$$

$$\pi_i = \sum_{t=21}^{30} 30 + \sum_{t=21}^{30} E_{it} - \sum_{t=21}^{30} g_{it} - v, \quad \text{if } \sum_{t=21}^{30} g_{1t} + g_{2t} + g_{3t} < T \quad (6)$$

Expectations play an important role, as one will only contribute as much as one thinks will be pivotal in reaching the threshold given their expectations of the other group members contributions (McBride 2006). With such coordination possibilities inherent to TPG games, we wish to examine what effect announcements of the future implementation of a threshold have on cooperative behaviour both before the change and after the change, and whether this effect is dependent on framing.

### 2.1.3 Loss-and-Risk Framed TPG game

The final variation in the treatments is the transition from a loss-framed PG game for 20 periods, into a loss-framed TPG game for 10 periods where the negative impact from not reaching the threshold only exists with a certain probability ( $p$ ). The decision to only use a *loss-framed* risk treatment is to maximise comparability with other studies utilising the same form of risk and also to more realistically model the prospects of the inherent riskiness of dangerous climate change from tipping over a threshold, which incorporates elements of scientific uncertainty and environmental resilience uncertainty (Milinski et al. 2008; Hasson et al. 2010; Santos & Pacheco 2011; Tavoni et al. 2011). The expected payoff for an individual after 10 periods of the risky-impact threshold TPG game is:

$$E(\pi_i) = \sum_{t=21}^{30} 30 + \sum_{t=21}^{30} E_{it} - \sum_{t=21}^{30} g_{it}, \quad \text{if } \sum_{t=21}^{30} g_{1t} + g_{2t} + g_{3t} \geq T \quad (5)$$

$$E(\pi_i) = \sum_{t=21}^{30} 30 + \sum_{t=21}^{30} E_{it} - \sum_{t=21}^{30} g_{it} - pv, \quad \text{if } \sum_{t=21}^{30} g_{1t} + g_{2t} + g_{3t} < T \quad (6)$$

In this treatment the risk of negative impact from not reaching the threshold is set at 50%, a risk rate used in Tavoni et al. (2011) and Milinski et al. (2008). Whether the impact occurred for groups with cumulative contributions lower than the threshold level in period 30 was decided by the computer generating a random number between 0 and 1 for each group. If the random number was less than or equal to 0.5 the negative impact occurred and each group member lost 300 tokens; if it was greater than 0.5 the negative impact did not occur and group members only lost the contributions they invested into the group account over the 10 periods.

## **3. Results**

Appendix B provides summary statistics for each treatment including the demographic data from the surveys. The table provides evidence that there are no systematic variations between treatments with regards to demographics, yet in all subsequent individual-level regressions demographic control variables are included for further guarantee against spurious effects.

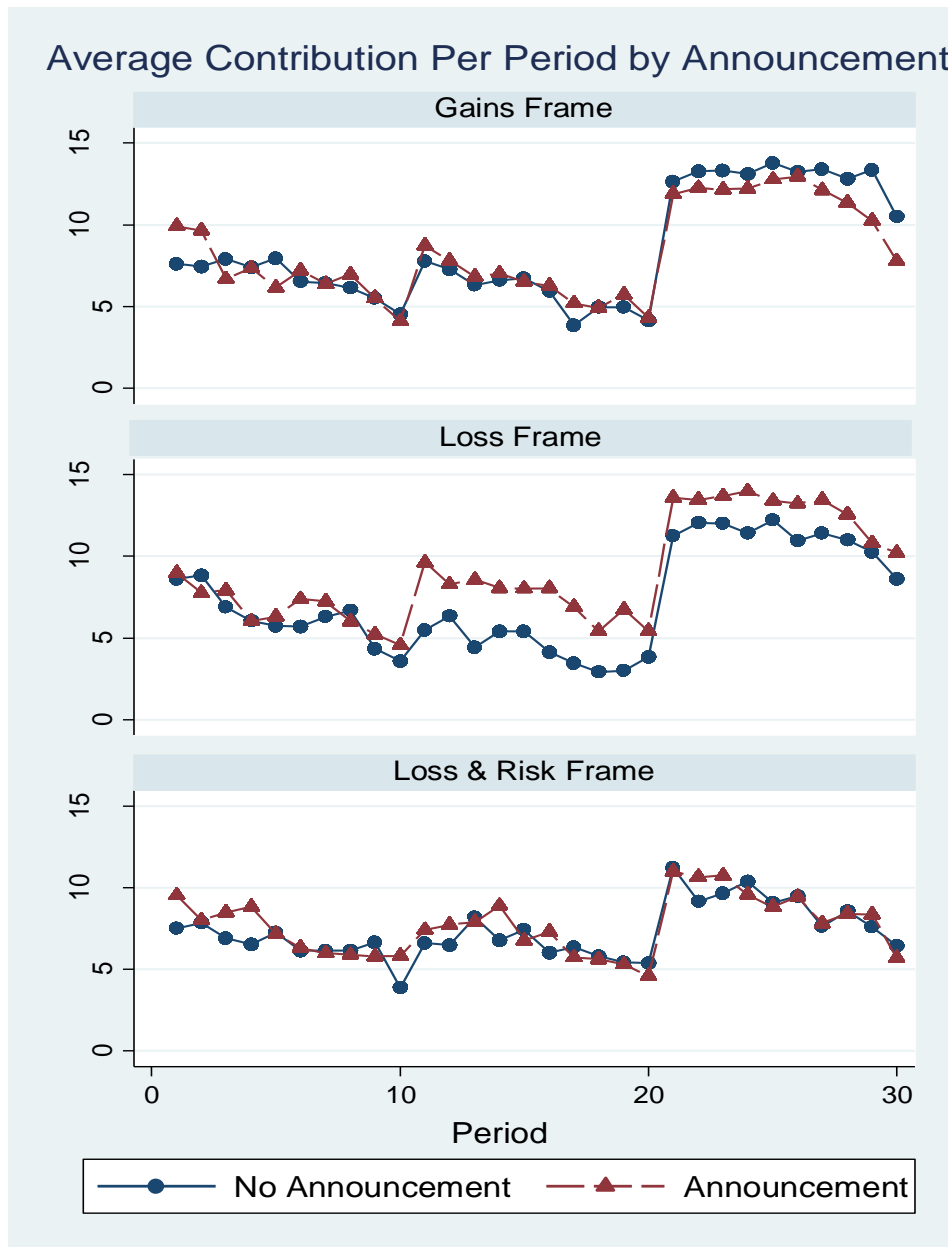
The analysis of the announcement effect is split into two sections relating to the adjustment effect (during the 10 periods before the implementation of the new institution whilst the announcements are repeatedly being made) and the adaptation effect (during the 10 periods after

the implementation of the new institution). Section 3.1 will discuss the adjustment effect on current subject behaviour and Section 3.2 will explain the results of the adaptation effect; both under different framing and risk contexts.

### **3.1 Adjustment Effect during Announcement Period: Periods 11-20**

*Result 1: Announcements of institutional change (or regime shifts) cause a significant and positive contribution adjustment effect in the Loss Treatments, but they do not lead to a contribution adjustment effect in the Gains or the Loss-and-Risk Treatments.*

In order to examine whether the announcements of a future regime or institutional change impact subject contribution behaviour during the ten periods where the announcement of impending future rule change were made, but before the actual implementation of the regime change (which was implemented from period 21-30), we initially ran some non-parametric tests on contribution levels. To test this announcement effect, we pooled the announcement and no-announcement treatments for each frame and ran a series of Kruskal-Wallis tests (results in Appendix C). In the Loss Treatments (LCN/LCA) contribution was shown to be significantly higher in LCA relative to LCN ( $p=0.0001$ ). However, in both the Gains Treatments (GCN/GCA) and the Loss-and-Risk Treatments' (LRN/LRA) PG games there were no significant differences between the contribution levels in the announcement and no-announcement treatments for the periods 11-20 (GCN/GCA:  $p=0.253$ ; LRN/LRA:  $p=0.335$ ). Figure 1 and Appendix D showing average contribution in each period for all treatments support this finding. The average contribution over periods 11-20 in the Loss Treatments with announcements is 15.33% higher than that of the Loss Treatments with no-announcement, which is a significant increase from the two treatments average contribution difference in periods 1-10 of 2.34%. Figure 1 and Appendix D also illustrate that in the other two frames, the contribution levels between the announcement and no-announcement treatments do not diverge substantially. The announcement treatment has only 2.43% and 1.37% percent higher average contributions over periods 11-20 for the Gains Treatments and the Loss-and-Risk Treatments, respectively.



**Figure 1 Average contribution per period in each treatment**

To further unpack these findings Tobit regressions were run for each framing context in table 3. In each regression the dependent variable is contribution and demographic controls are included. All standard errors are robust and clustered at the individual level. The variables *Risk Attitude (RA)* and *Loss Aversion (LA) index* are variables derived from a subject's two gamble choices in the pre-experiment choice tasks<sup>5</sup>. The *Risk Attitude* variable is a measure of an individual's overall risk preferences and is the sum of an individual's gamble choices in the

<sup>5</sup> Analysis of the Gamble-choice tasks results is available upon request from the authors.

initial risk experiment, with values ranging from 2 to 10. The *Risk Attitude* variable is decreasing in risk aversion and increasing in risk taking behaviour. The *Loss Aversion (LA) index* variable is a crude measure of a subject's loss aversion, created following the logic of Eckel & Grossman (2008). It is defined as a subject's gamble choice in the gains frame minus their gamble choice in the loss frame which gives each subject a value between -4 and 4<sup>6</sup>. A high LA index means an individual is more risk averse in the presence of losses; and a low LA index means an individual is less risk averse in the presence of losses. For the purposes of this paper loss aversion will be defined as increasingly risk-averse behaviour in the presence of loss prospects (for a thorough explanation and justification of the LA index variable, see the supplementary online materials).

The main result from Table 3 is found in the dummy variable *announcement*. The announcements are made (in the announcement treatments) from periods 11-20, therefore we do not expect the announcement and no-announcement treatments to be significantly different in periods 1-10 and this is included in the table as a baseline. The adjustment effect would therefore only be evidenced by significant differences in contribution behaviour during periods 11-20. In both the Gains (columns 1 and 2) and the Loss-and-Risk Treatments (columns 5 and 6), the announcement dummy is insignificant in both periods 1-10 and 11-20, implying that the announcement does not cause any contribution adjustment effects. However, in the Loss Treatments (columns 3 and 4) we see that the announcement causes a large, positive and very significant ( $p= 0.000$ ) impact on contribution. In the Loss Treatments, receiving the announcement increases the amount an average individual contributes by 4.7 (23.5%) tokens in periods 11-20, *ceteris paribus*. It is important that the announcement variable is not significant for periods 1-10 in the Loss Treatments. This phase was before the announcements began (period

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<sup>6</sup> All the following analyses' results remain the same using a reworked definition of our *LA Index* variable using natural logs, inspired by Lopes & Oden (1999).

**Table 3 Contribution Adjustment Effects<sup>7</sup>**

Regression: Tobit	Dependent Variable: Contribution					
	Gains Frame		Loss Frame		Loss-and-Risk Frame	
	(1)	(2)	(3)	(4)	(5)	(6)
Independent Variables	Periods 1-10	Periods 11-20	Periods 1-10	Periods 11-20	Periods 1-10	Periods 11-20
Lagged sum of others' contribution	0.230*** (0.0402)	0.323*** (0.0480)	0.286*** (0.0436)	0.478*** (0.0584)	0.226*** (0.0387)	0.278*** (0.0522)
Announcement	0.753 (1.133)	0.821 (1.234)	1.744 (1.269)	4.693*** (1.318)	-0.279 (1.124)	-0.809 (1.526)
Risk Attitude (RA)	-0.369 (0.339)	-0.196 (0.332)	-0.523 (0.324)	-0.342 (0.361)	-0.225 (0.276)	0.0842 (0.397)
Loss Aversion index (LA)	0.704 (0.428)	0.276 (0.479)	-0.311 (0.378)	-0.582 (0.432)	-0.312 (0.333)	-0.657 (0.597)
Period	-0.525*** (0.135)	-0.653*** (0.142)	-0.519*** (0.147)	-0.555*** (0.167)	-0.464*** (0.113)	-0.476*** (0.115)
Constant	4.814** (2.414)	11.79*** (3.194)	4.271 (2.920)	6.030 (4.520)	7.549*** (2.672)	7.321* (3.887)
Demographic Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	837	930	945	1,050	999	1,110
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pseudo R <sup>2</sup>	0.0233	0.0367	0.0303	0.0633	0.0238	0.0186

Robust standard errors in parentheses  
\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

<sup>7</sup> The significance of results from all the regressions described in this paper are robust to the exclusion of the Loss Aversion index variable and the Sum of Individual's Gamble choices variable.

11) and indicates that without the announcement these two treatments have no significant differences in contributions

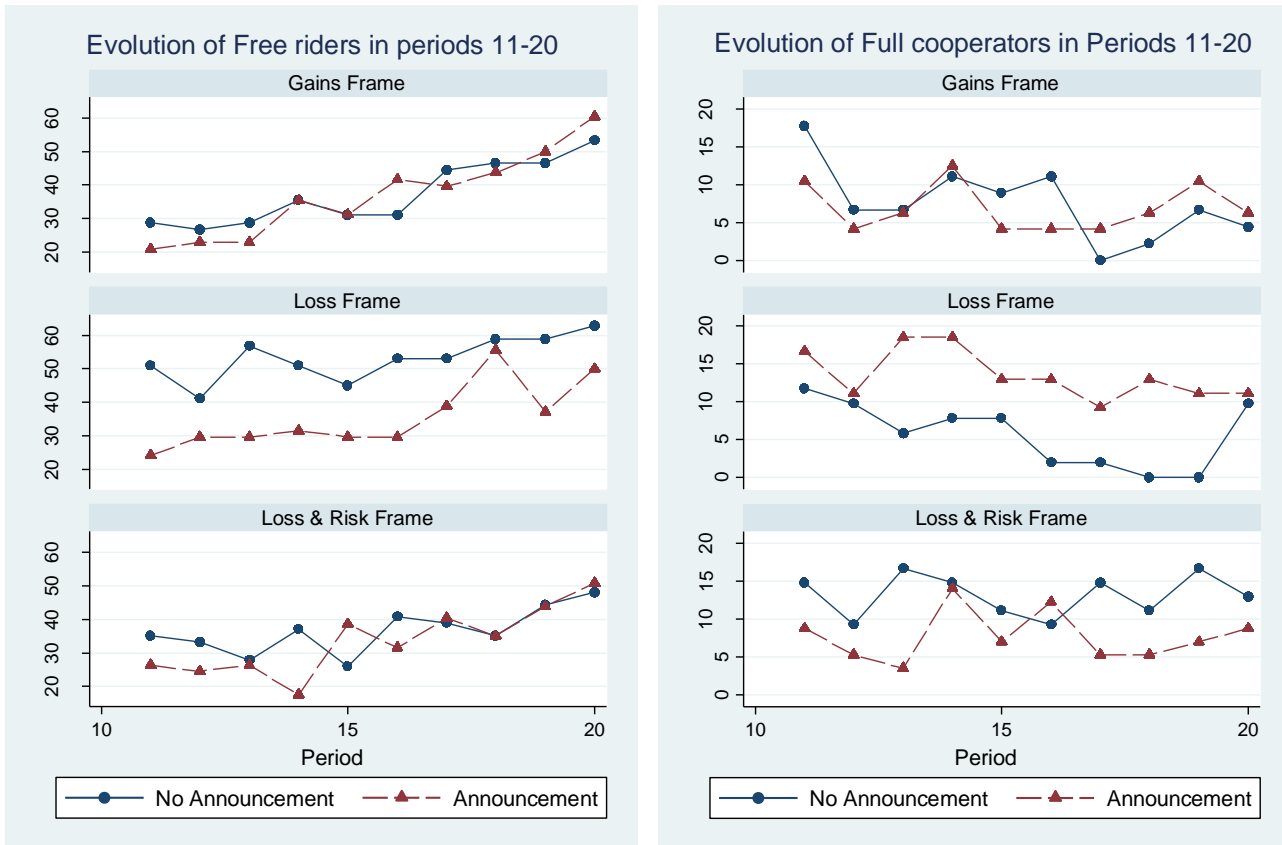
For all columns the variable *lagged sum of others' contribution*, which is how much the rest of one's group contributed in the previous period, is positive and significant at the 1% level for periods 1-10 and 11-20. This implies that a highly important predictor of current contribution in all frames is how much the rest of the group contributed in the previous period. Neither the Risk Attitude nor the LA index variables show any real significance in any of the columns.

Next, we would like to consider to what extent different behavioral types appeared during the adjustment period and how the announcements influenced their propensity to emerge under different framing contexts. In order to do so we considered the likelihood of either full cooperators or free-riders emerging during these 10 periods.

*Result 2: Full cooperation increases significantly in the Loss Treatment, during the adjustment periods (11-20) when repeated announcements about the institutional change were being made. Furthermore, the announcements significantly decrease Free-riding during the adjustment periods of the Loss Treatment. However, in the Gains and Loss-and-Risk Treatments there is no evidence of any such player-strategy adjustment effects.*

In order to be a full cooperator a subject must have contributed their full endowment of 20 tokens to the group account for the period; and in order to be a free rider a subject must have contributed 0 tokens to the group account for the period. We created a dummy variable for each of these two player types, equal to 1 if their definition is met and equal to 0 if not.

Figure 3 provides an illustration of the percentage of subjects playing as a free rider or full cooperator in each period for periods 11-20. The patterns shown in this graph suggest that it is only in the Loss Treatments where they announcements had any influence on player strategies: increasing the propensity to fully cooperate and decreasing the propensity to free ride. To further investigate whether the announcement changes the likelihood of a subject being either a full cooperator or a free rider in each of the three different framing contexts we employed Kruskal-



**Figure 3 Evolution of Player Strategies in Periods 11-20**

Wallis non-parametric tests (results in Appendix C) and a series of logit regressions in Appendix E. Four regressions were run for each frame: periods 1-10 and 11-20 with the dependent variable the dummy for being a full cooperator; and periods 1-10 and 11-20 with the dependent variable the dummy for being a free rider. All regressions report logit coefficients and robust standard errors clustered at the individual level.

In the Gains Treatments Kruskal-Wallis tests find no significant differences between the GCN and GCA treatments with regards to the numbers of full cooperators ( $p=0.6886$ ) and the numbers of free riders ( $p=0.8848$ ) for periods 11-20. This is confirmed by columns 1-4 of Appendix E which shows the announcement dummy to be an insignificant predictor on the likelihood of an average subject being either a full cooperator or a free rider in the Gains Treatments.

In the context of the Loss Treatments, initial Kruskal-Wallis tests for the periods 11-20 indicate that the announcement has a significant and positive influence on the numbers of full cooperators



( $p=0.0001$ ) and a significant and negative impact on the numbers of free riders ( $p=0.0001$ ). This finding is supported by columns 5-8 of Appendix E, which also shows that the announcement dummy is only significant in each regression for periods 11-20, after the announcements have been made. The marginal effect of the announcements in the Loss Treatments is an increase in the likelihood that the average subject is a full cooperater by 4.03% ( $p= 0.032$ ) and a decrease in the likelihood that the average subject is a free rider by 14.25% ( $p= 0.012$ ).

Kruskal-Wallis tests for the Loss-and-Risk Treatments suggest no significant differences in the number of free riders ( $p= 0.2706$ ) between LRN and LRA, but significantly less full cooperaters in LRA ( $p= 0.0030$ ) in periods 11-20. The logit regressions in columns 9-12 of Appendix E corroborate the insignificant impact of the announcement with regards to the likelihood of free riders, but do not support the finding of the announcements having any significant effect on the likelihood of full cooperaters. This shows that once other variables are controlled for, the announcement does not have any significant adjustment effect on the likelihood of player-types in the Loss-and-Risk Treatments.

These findings imply that the announcement's positive adjustment effect of higher contributions found in the loss frame in *Result 1* is driven by the announcement causing significantly more people to fully cooperate and significantly fewer people to completely free-ride. One might see this as the announcement causing greater overall cooperation in the loss frame. This interpretation is also strengthened by the fact that there are no contribution adjustment effects for the announcements in the gains and loss-and-risk frames and, correspondingly, no player-type adjustment effects for either of these two frames.

In terms of climate change, results 1 and 2 imply that loss-framed announcements in the form of early warnings about of future climate thresholds (or pending regime shifts) can influence country emission abatement behaviour positively by encouraging cooperation and the signaling of cooperative intentions at early stages. Our results from the Loss-and-Risk Treatments, however, indicate that it is vital for such announcements to be as accurate as possible, and show the importance of rigorous climate modeling in order to reduce the uncertainty of future forecasts.

### 3.2 Adaptation Effect – Periods 21-30

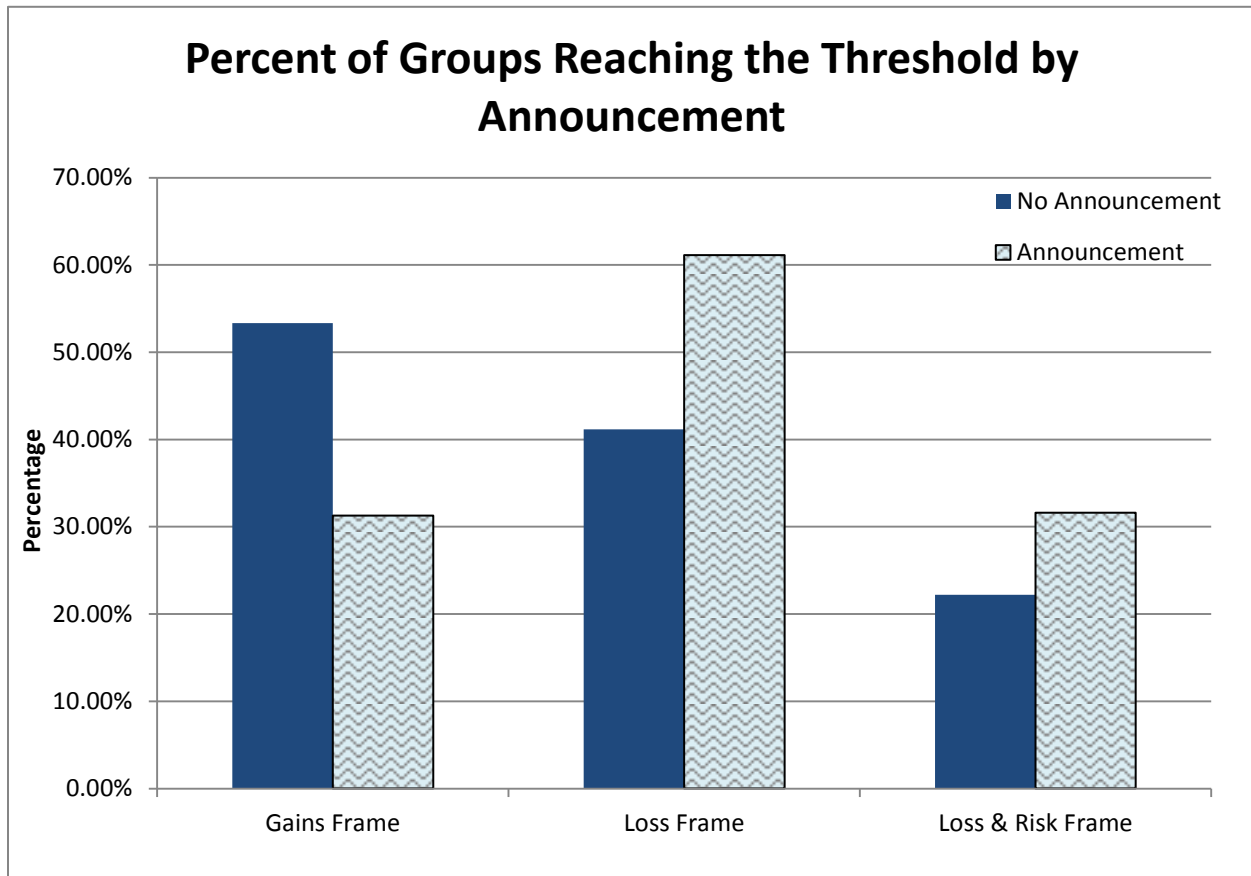
*Result 3: A clear adaptation effect due to early announcements is present in the Loss Treatments after the regime shift occurs. Announcements in early periods significantly increase the likelihood of groups reaching the threshold after the implementation of the new institution or regime shift. However, the announcement significantly decreases the likelihood of groups reaching the threshold in the Gains Treatment; and the announcement has no significant impact on the probability of groups reaching the threshold in the Loss-and-Risk Treatment.*

Figure 1 shows that the implementation of the threshold rules, beginning in period 21, results in significantly increasing the average contribution per period in all treatments. This rise in contribution is to be expected, as the threshold game reduces the conflict between individual and collective interests inherent to the normal public goods game; and implies increased benefit to the individual for coordinated cooperation (Cadsby & Maynes 1999; Abele et al. 2010). However, the trends between the announcement and no-announcement treatments in Figure 1 also seem to suggest that the prior announcements cause increased contribution in the Loss Treatment, decreased contribution in the Gains Treatment, and no real impact in the Loss-and-Risk Treatment. Kruskal-Wallis tests confirm the significance of these announcement effects on contribution in the gains frame ( $p=0.0166$ ) and the loss frame ( $p= 0.0001$ ) and the insignificant effects in the loss-and-risk frame ( $p= 0.8239$ ).

**Table 4 Groups that reached the threshold by treatment and announcement**

	<u>No Announcement</u>			<u>Announcement</u>		
	<b>Total Groups in Treatment</b>	<b>Total Groups Reached Threshold</b>	<b>Percentage of Groups Reached Threshold</b>	<b>Total Groups in Treatment</b>	<b>Total Groups Reached Threshold</b>	<b>Percentage of Groups Reached Threshold</b>
Gains Frame	15	8	53.33%	16	5	31.25%
Loss Frame	17	7	41.18%	18	11	61.11%
Loss-and-Risk Frame	18	4	22.22%	19	6	31.58%

Table 4 and Figure 4 show that these announcement effects on contribution in the gains and Loss Treatments correspond to similar patterns in the number of groups who reach or exceed the threshold in period 30. It can be seen that in the announcement treatment 22.08% fewer groups reaching the threshold relative to the no-announcement treatment in the Gains frame. Whereas the announcement treatments in the Loss and the Loss-and-Risk frames results in 19.93% and 9.36% respectively, more groups reaching the threshold compared to the no-announcement treatments.



**Figure 4 Percentage of Groups reaching the threshold in each treatment**

These adaptation effects of announcements on the likelihood of a group reaching the threshold in period 30 are further explored in logit regressions reporting coefficients with robust standard errors clustered at the group-level (Appendix F). The regressions confirm the results seen in the non-parametric tests and graphs, except in the Loss-and-Risk Treatment where the higher propensity of groups to reach the threshold in the announcement treatment is not significant ( $p=$

0.181). However, the Appendix F regressions suffer from small sample sizes due to their focus on the 30<sup>th</sup> period and exhibit small Wald  $\chi^2$  statistics. Thus, to improve confidence in our results, regressions using larger sample sizes are required.

This was done by changing the dependent variable to a dummy variable *Average Threshold Required* (AT) which equals 1 if a group reached or exceeded the average required group account contributions per period to reach the threshold in period 30 ( $AT = \frac{450}{10} = 45$  tokens). Using this dependent variable, regressions could then be run over the periods 21-30, increasing the sample size. Table 5 reports logit coefficients with robust standard errors clustered at the group-level. The variables *Group Loss Aversion (LA) Index* and *Group Risk Attitude* are group-level variables that represent the total loss aversion and risk preference of each group by taking the sum of individual members' measures.

**Table 5 Likelihood of an Average Group Reaching the Average Threshold Required each Period in Different Frames**

Regression: Logit	Dependent Variable: Average Threshold Required for periods 21-30 (0/1)		
Independent Variables	Gains Frame	Loss Frame	Loss and Risk Frame
Reached Average Threshold in previous period (0/1)	2.535*** (0.619)	2.454*** (0.371)	3.201*** (0.435)
Announcement	-0.843** (0.402)	0.635* (0.354)	0.337 (0.394)
Group Loss Aversion (LA) Index	-0.225*** (0.0759)	-0.0724 (0.0698)	0.0784 (0.0837)
Group Risk Attitude	0.183** (0.0746)	-0.0703 (0.0466)	-0.0120 (0.0439)
Period	-0.120* (0.0670)	-0.129*** (0.0398)	-0.123*** (0.0355)
Constant	-0.423 (2.075)	2.774** (1.299)	0.970 (0.954)
Log pseudo-likelihood	-433.29	-544.47	-448.21
Observations	930	1,050	1110
Wald $\chi^2$	44.36	88.95	61.46
Prob > $\chi^2$	0.0000	0.0000	0.0000
Pseudo R <sup>2</sup>	0.3277	0.2479	0.3172

Robust Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

The results in Table 5 corroborate the initial analysis. In terms of marginal effects, the announcements in the Loss Treatment cause an average group to be 15.53% ( $p=0.067$ ) more likely to reach or exceed the 45 token average required threshold (AT) each period. Whereas, announcements in the Gains Treatment lead to a -20.76% ( $p=0.031$ ) marginal effect on the probability of an average group reaching the AT each period. Finally, in the Loss-and-Risk Treatment the announcements have no significant impact. Important to note is the large, positive significance of a group reaching the AT in the previous period across all treatments. The models in Table 5 also exhibit better overall prediction for the variation in the dependent variable than Appendix F, with each regression having a high Wald  $\chi^2$  statistic.

*Result 4: There is some evidence that the announcements' adaptation effects on the likelihood of groups reaching the threshold may be driven by the announcements' influence on player-strategy choices, as found during the adjustment effect section.*

To investigate this we created two more player strategy types: fair-sharer and altruist. A fair-sharer is defined as a subject who contributes their fair share of the average required group account contribution per period, which is 45 tokens shared equally amongst all three group members ( $AT/3 = 15$  tokens). An altruist is defined as a subject that contributes anything more than their fair share; anything greater than 15 tokens. The fair-sharer strategy needs inclusion due to the TPG game creating a focal point of equitable sharing of responsibility to reach the threshold, whereas the altruist strategy is analogous to the full co-operator strategy observed during the adjustment periods.

Graphs of the evolution of player types (Appendix G) during the TPG game seem to support this causal mechanism of the announcements' adaptation effects on reaching the threshold. In the Loss Treatment, announcements seem to increase altruist strategies and decrease free riding (analogous to the announcements' player strategy effects observed in the adjustment periods), both of which would increase groups' likelihoods to reach the threshold by increasing contribution. Furthermore, announcements in the Gains Treatment appear to increase free riding and decrease fair-sharing, both of which decrease contributions and would explain the announcements' adaptation effect of lowering groups' likelihoods to reach the threshold. In the Loss-and-risk Treatment, the announcements don't seem to have any effect on player strategies

and this is consistent with the lack of adaptation effects on the likelihood of groups reaching the threshold in this treatment

However, the possibility of this explanation is tempered by the insignificance of announcement dummy variables in logit regressions on player strategy types for each Treatment (Appendices H, I and K). This implies that once other variables are controlled for, the announcements do not have any significant effects on player strategies after the implementation of the threshold institution.

*Result 5: Within groups that are successful in reaching the threshold in the final period of the TPG game in the Loss and Loss-and-Risk Treatments, the announcements seem to cause stronger, earlier cooperative action. Such an effect is not seen in the Gains Treatment.*

Finally, we also explore whether there is any difference between the groups that were successful in reaching the threshold in Period 30 without announcements and those that did it after being forewarned with announcements. Appendix K shows the graphs of the average group account contribution per period for groups that succeeded in reaching the threshold across Treatments and whether or not they received the announcements. The trends from the graphs show that in the Loss Treatment and the Loss-and-Risk Treatment, successful groups that received announcements made stronger, earlier cooperative action relative to successful groups that did not receive the announcement. This is reinforced by Kruskal-Wallis tests (Appendix C) on total group account contributions per period between no-announcement treatments and announcement treatments for the first half of the threshold phase (periods 21- 25) in both the Loss ( $p=0.0023$ ) and the Loss-and-Risk Treatments ( $p=0.0011$ ). This effect of strong, early action in successful groups is not present in the Gains Treatment ( $p=0.2368$ ).

However, this finding must be tempered by the observation that in both the Loss and the Loss-and-Risk Treatments, the announcement treatments have more successful groups and this might be biasing the Kruskal-Wallis tests. Nevertheless, such adaptation effects of strong, early action due to announcements have been found in Visser et al., (2014) who find that announcements of future punishment opportunities result in the increased and more effective early-utilisation of the

punishment institution, once it is implemented<sup>8</sup>.

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Results 3-5 imply that early warnings of climate change, when made in a loss frame, can significantly improve society's chances of avoiding a dangerous future climate threshold, relative to an unannounced discovery of future climate thresholds, by incentivising increased cooperation and coordination. Possibly this increased cooperation is due to the announcements increasing people's estimation of *their* contribution being pivotal and necessary to make the difference. The important role of subjective expectations of being pivotal have been well noted (e.g. (Rapoport & Eshed-Levy 1989; McBride 2006; Makris 2009; McBride 2010). This feeling of being pivotal might also explain the observation of stronger, early action by groups forewarned with announcements. This would have major implications for climate change policy, especially considering the importance that *The Stern Review* places on strong, early action in order to solve global warming (Tol & Yohe 2006) and the positive effects that early signals of cooperative intent have on the successful provision of threshold public goods in sequential games (Dannenberget al. 2011; Normann & Rau 2011).

*Result 6: In the Gains and Loss Frames with announcements, groups with higher Group Loss Aversion (LA) index scores are less likely to reach the threshold in Period 30. This seems to be mediated by higher individual-level Loss Aversion (LA) index scores decreasing the propensity of subjects to play the altruist strategy in the announcements treatments of the Gains and Loss Frames. There is no differential effect of Loss Aversion on reaching the threshold in the Loss-and-risk Frame between the announcement and no-announcement treatments.*

Rerunning the regressions in Table 5 and isolating each of the 6 treatments, as shown in Table 6, reveals interesting interactions between the *Loss Aversion (LA) index* and the *Announcements* in the Gains and Loss Treatments with regards to the likelihood of groups reaching the threshold in the final period of the TPG game.

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<sup>8</sup> Important to note is that the future punishment opportunities are inherently framed in the context of losses, it would be interesting to see if announcements of future reward opportunities result in the same lack of impact as witnessed in the present studies gains frame.

**Table 6 Likelihood of an Average Group Reaching the Average Threshold Required each Period in each Treatment**

Regression: Logit		Dependent Variable: Average Threshold Required for periods 21-30 (0/1)					
Independent Variables	Gains Frame		Loss Frame		Loss-and-Risk Frame		
	GCN	GCA	LCN	LCA	LRN	LRA	
Reached Average Threshold in previous period (0/1)	2.294** (1.042)	2.548*** (0.756)	3.065*** (0.603)	1.926*** (0.468)	3.139*** (0.598)	3.253*** (0.650)	
Group Loss Aversion (LA) Index	-0.216 (0.154)	-0.264*** (0.0912)	0.0236 (0.103)	-0.173** (0.0764)	0.118 (0.111)	0.0736 (0.139)	
Group Risk Attitude	0.357*** (0.119)	0.0891 (0.0765)	-0.108 (0.0711)	-0.0341 (0.0583)	-0.0628 (0.0929)	0.00165 (0.0493)	
Period	-0.132 (0.107)	-0.0889 (0.0834)	-0.157** (0.0618)	-0.111* (0.0583)	-0.0812 (0.0565)	-0.158*** (0.0421)	
Constant	-2.549 (3.196)	-0.503 (2.558)	3.925** (1.822)	2.650 (1.883)	0.621 (1.851)	1.966* (1.155)	
Log pseudo-likelihood	-208.69	-215.90	-227.74	-305.08	-207.29	-239.47	
Observations	450	480	510	540	540	570	
Wald chi <sup>2</sup>	23.34	35.20	45.16	28.00	28.44	34.19	
Prob > chi <sup>2</sup>	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	
Pseudo R <sup>2</sup>	0.3161	0.3437	0.3258	0.1823	0.3098	0.3219	

Robust standard errors in parentheses  
 \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

In the Announcement treatments of both the Gains and Loss Frames (GCA/LCA) it appears that groups which are more loss averse are on average significantly less likely to reach the average required threshold each period. The observation that a group's loss aversion score does not predict their average required threshold outcome in the No-Announcement treatments in the Gains and Loss Frames suggests that the Announcements somehow trigger subjects' loss aversion to become important. This pattern is not evident in the Loss-and-Risk Frame, indicating that the presence of uncertainty somehow mitigates the announcements' interaction with loss aversion. Also evident from Table 6 is that *Group Risk Attitude* is only significant in the No-Announcement Gains Treatment, and its interpretation is that as a group's risk-taking behaviour increases, so too does their propensity to reach the average required threshold each period.

In order to uncover how increased loss aversion leads to lower likelihoods of groups reaching



the threshold in Treatments GCA and LCA, appendix L reports logit coefficients of the predictors of player-strategy choices during the TPG game with the 4 treatments in the Gains and Loss Frames split up. These regressions show that in announcement treatments in the Gains and Loss Frames, a higher *Loss Aversion index* is correlated with a higher likelihood of choosing the altruist strategy. This result may be driving the findings in Table 6, as higher levels of altruists means more contribution and a greater chance of groups reaching the average required threshold each period. Appendix L also suggests that the significance of *Group Risk Attitude* in the No-Announcement Gains treatment is being driven by higher risk-taking behaviour in this treatment being correlated with a diminished propensity to free ride.

The practical implications of this result highlight the importance of strategic thought when delivering early warnings of future climate regime shifts. Perhaps Loss Aversion on a country scale relates to how much climate damage a country could take without it massively impacting their citizens, for example the United States would be less loss averse than India. If this is the case, our results show that early warning announcements could cause highly loss-averse countries to be less likely to cooperate fully and choose altruist strategies, thereby decreasing the chances that their group will succeed in reducing carbon emissions sufficiently. Announcements seem to have a seemingly ‘cynical effect’ on the highly loss averse. Policy-makers must therefore be sure to group less loss averse countries together with the highly loss averse countries in discussions so as to ensure that climate strategy formulation and implementation is not thwarted by the ‘cynical effect’.

#### **4. Discussion & Conclusion**

It appears that the context in which announcements of a future regime change are made significantly affects their impact on peoples’ behaviour. When the situation is framed in the Loss domain, the announcements cause positive adjustment effects (before the implementation of the regime change) in the form of significantly higher contributions, mediated through increasing the instances of full-cooperators and diminishing the instances of free-riders. Additionally, once the regime change is implemented, those groups previously warned through announcements face positive adaptation effects of significantly higher likelihoods of reaching the required threshold level of contributions. The announcements adaptation effects may be working through increasing

the propensity of individuals to play an altruist strategy and decreasing their propensity to free-ride.

However, when the context is framed in the Gains domain, the announcements do not have any adjustment effects on the cooperative behaviour of individuals, and have the negative impact of significantly reducing the likelihood that groups will meet the required threshold after the regime change has been implemented (adaptation effect). There is weak evidence that this is partly working through announcements reducing the number of subjects playing the fair-share strategy and increasing the levels of free-riders.

Our third context supports the findings in the previous literature on collective-risk social dilemmas by showing that the inclusion of impact risk in the Loss Treatment reduces contributions and the numbers of groups reaching the threshold, from 41.18% to 22.22%. Our results also show the negative impact of risk on the effectiveness of announcements in Loss Treatment. The inclusion of the 50% probability of a negative impact if group contributions do not meet the threshold in the Loss Treatment causes the announcements to have no significant adjustment or adaptation effects.

This paper makes a unique contribution to the experimental economics literature by being the first study to explore framing effects of announcements of future institutional change. This paper also represents a shift towards the use of announcements as exogenously given, credible warning interventions of future thresholds.

The findings of the current paper hold relevant insights in terms of the climate change problem and how to increase the chances that society will avoid crossing a dangerous climate threshold in the future. We find that announcements have the most positive impact on the effectiveness of institutional change in the Loss Frame which bodes well for the current scientific announcements of future climate thresholds as they are most naturally explained in terms of loss minimization. Our findings suggest that early warnings of future climate thresholds can increase society's contributions to carbon emissions abatement before thresholds become part of the institutional environment or new regime, possibly due to members of society using the periods in which early warnings occur as an opportunity to signal cooperative intentions in the light of future-needed

coordination. Furthermore, our results show that early warnings of climate change also significantly increase the likelihood of our society avoiding a dangerous climate threshold after regime change occurs. This could work by increasing individual country's estimation of their contribution being pivotal in avoiding the threshold. These insights support the propositions that the benefits of early warning stem from increased preparedness and coordination (UNISDR 2010; Alfieri et al. 2012).

However, we also see that introducing risk of loss, rather than certain loss, from not reaching the threshold negates the positive announcement effects. Climate policy-makers should take from this that greater impact certainty needs to be made explicit if current announcements of dangerous climate tipping points are to have any effect.

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**Appendix A - Gamble-Choice Task with Expected Payoffs and Risk**

Choice	Event	Probability (%)	Payoff		Expected payoff		Risk*	CRRA ranges**
			Loss	No-Loss	Loss	No-Loss		
1	A	50	14	24	14	24	0	r>1.6
	B	50	14	24				
2	A	50	24	34	16	26	8	0.53<r<1.6
	B	50	8	18				
3	A	50	34	44	18	28	16	0.30<r<0.53
	B	50	2	12				
4	A	50	44	54	20	30	24	0.15<r<0.30
	B	50	-4	6				
5	A	50	54	64	22	32	32	r<0.15
	B	50	-10	0				

\*Measured as standard deviation of expected payoff.

\*\*Calculated as the range of r in the function  $U=x(1-r)/(1-r)$  for which the subject chooses each gamble assuming constant relative risk aversion

Subjects were asked to complete two 5-choice gamble tasks with real financial stakes, in order to elicit risk and loss attitudes. The method includes two frames: a no-loss frame, where the gambles only contain outcomes of greater than or equal to zero; and a loss frame, where two of the riskiest gambles include the prospect of losing some or all of a subject’s show-up fee. A rough estimation of loss aversion can then be revealed by comparing subjects’ choices in the different frames. Whereas Eckel & Grossman (2008b) utilised a between-subject design to measure the differences in loss and risk attitudes between men and women, we utilised a within-subject design so that we have measures of risk and loss attitudes for each subject. Subjects had to make choose one of five options in two consecutive decision frames (loss & no-loss) whereby each choice had a 50/50 probability to give the subject the value A or B. Options 1 to 5 were increasing in riskiness in both decision frames. In our experiment, the loss framed gamble-choice task was played first followed by the no-loss frame. Subjects were told that the choices they make in the gamble-choice experiments might result in the loss of some or all of the R10 show-up. Outcomes of the 50/50 gambles were then decided at the end of the session by the computers

generating a random number for each subject. If that number was less than or equal to 0.5, then value A would be paid to the subject; otherwise value B was paid to the subject.

## Appendix B - Summary Statistics

Treatments	GCN	GCA	LCN	LCA	LRN	LRA	All
Number of Subjects	45	48	51	54	54	57	<b>309</b>
Average Contribution over all games	8.52 [7.19]	8.30 [7.11]	7.27 [7.29]	9.03 [7.47]	7.29 [7.19]	7.65 [7.05]	<b>7.99</b> <b>[7.24]</b>
Male	0.533 [0.499]	0.438 [0.496]	0.588 [0.492]	0.519 [0.500]	0.426 [0.495]	0.474 [0.499]	<b>0.495</b> <b>[0.500]</b>
Black	0.556 [0.497]	0.625 [0.484]	0.706 [0.456]	0.685 [.465]	0.815 [0.389]	0.684 [0.465]	<b>0.683</b> <b>[0.465]</b>
White	0.178 [0.382]	0.146 [0.353]	0.059 [0.235]	0.093 [0.290]	0.093 [0.290]	0.14 [0.347]	<b>0.117</b> <b>[0.321]</b>
Coloured	0.089 [0.285]	0.125 [0.330]	0.098 [0.297]	0.111 [0.314]	0.019 [0.135]	0.053 [0.223]	<b>0.081</b> <b>[0.273]</b>
Other Race	0.178 [0.382]	0.104 [0.306]	0.137 [0.344]	0.111 [0.314]	0.074 [0.262]	0.123 [0.328]	<b>0.12</b> <b>[0.325]</b>
Below 24 years old	0.822 [0.382]	0.896 [0.306]	0.941 [0.235]	0.963 [0.189]	0.944 [0.229]	0.912 [0.283]	<b>0.916</b> <b>[0.278]</b>
25 years old and older	0.178 [0.382]	0.104 [0.306]	0.059 [0.235]	0.037 [0.189]	0.056 [0.229]	0.088 [0.283]	<b>0.085</b> <b>[0.278]</b>
Humanities	0.378 [0.485]	0.313 [0.464]	0.196 [0.397]	0.093 [0.290]	0.13 [0.336]	0.404 [0.491]	<b>0.25</b> <b>[0.433]</b>
Commerce	0.333 [0.472]	0.375 [0.484]	0.353 [0.478]	0.593 [0.492]	0.5 [0.500]	0.281 [0.449]	<b>0.408</b> <b>[0.491]</b>
Other Faculty	0.289 [0.453]	0.313 [0.464]	0.451 [0.498]	0.315 [0.465]	0.37 [0.483]	0.316 [0.465]	<b>0.343</b> <b>[0.475]</b>
High Income	0.044 [0.206]	0.042 [0.200]	0.098 [0.297]	0.056 [0.229]	0 [0]	0.018 [0.131]	<b>0.042</b> <b>[0.201]</b>
Middle Income	0.6 [0.490]	0.542 [0.498]	0.51 [0.500]	0.611 [0.488]	0.611 [0.488]	0.579 [0.494]	<b>0.576</b> <b>[0.494]</b>
Low Income	0.356 [0.479]	0.417 [0.493]	0.392 [0.488]	0.333 [0.472]	0.389 [0.488]	0.404 [0.491]	<b>0.382</b> <b>[0.486]</b>
Smoker	0.133 [0.340]	0.146 [0.353]	0.137 [0.344]	0.148 [0.355]	0.093 [0.290]	0.105 [0.307]	<b>0.126</b> <b>[0.332]</b>

Standard Deviations in square brackets

**Appendix C - Kruskal-Wallis Tests between Announcement and No-Announcement Treatments for each Frame**

		Period 1-10		Period 11-20		Period 21-30	
		Ranksums	p-value	Ranksums	p-value	Ranksums	p-value
Variable: <b>Contribution</b>							
Between GCN & GCA	GCN=206406.50 GCA= 226508.50	0.4448	GCN= 204928.50 GCA=227986.50	0.253	GCN= 218914.50 GCA= 214000.50	0.0166	
Between LCN & LCA	LCN=263187.00 LCA=288588.00	0.3124	LCN=235238.50 LCA=316536.50	0.0001	LCN=249107.50 LCA=302667.50	0.0001	
Between LRN & LRA	LRN=289708.50 LRA=326896.50	0.0502	LRN=294950.50 LRA=321654.50	0.335	LRN= 298815.00 LRA=317790.00	0.8239	
Variable: <b>Full Cooperator (0/1)</b>							
Between GCN & GCA	GCN=205635.00 GCA=227280.00	0.0494	GCN=210210.00 GCA= 222705.00	0.6886	GCN=208830.00 GCA=224085.00	0.8223	
Between LCN & LCA	LCN=264240.00 LCA= 287535.00	0.1193	LCN=257220.00 LCA=294555.00	0.0001	LCN=258615.00 LCA= 293160.00	0.0065	
Between LRN & LRA	LRN=300150.00 LRA=316455.00	0.9458	LRN=308325.00 LRA=308280.00	0.003	LRN=301215.00 LRA=315390.00	0.7058	
Variable: <b>Free Rider (0/1)</b>							
Between GCN & GCA	GCN=215325.00 GCA=217590.00	0.0732	GCN=209970.00 GCA=222945.00	0.8848	GCN=202695.00 GCA=230220.00	0.0093	
Between LCN & LCA	LCN=271725.00 LCA=280050.00	0.3657	LCN=292215.00 LCA=259560.00	0.0001	LCN=282030.00 LCA=269745.00	0.0001	
Between LRN & LRA	LRN=307785.00 LRA= 308820.00	0.0665	LRN=304830.00 LRA= 311775.00	0.2706	LRN=300420.00 LRA=316185.00	0.9174	
Variable: <b>Group Account Contributions</b>						Periods 21-25	
						Ranksums	p-value
Between GCN & GCA	GCN= 12201.00 GCA=6909.00						0.2368
Between LCN & LCA	LCN=12342.00 LCA=24243.00						0.0023
Between LRN & LRA	LRN= 3711.00 LRA=7614.00						0.0011

**Appendix D - Average contribution per period and for each 10 period phase in each treatment**

Period	Gains Frame		Loss Frame		Loss-and-Risk Frame	
	GCN	GCA	LCN	LCA	LRN	LRA
	Average contribution per period (percent)					
1	38.00	49.58	43.04	44.81	37.41	47.63
2	37.33	48.33	44.22	38.80	39.26	40.00
3	39.67	33.44	34.51	39.63	34.54	42.46
4	37.11	36.77	30.29	30.19	32.69	44.12
5	39.78	30.83	28.63	31.48	36.30	35.88
6	32.67	36.04	28.43	36.94	30.74	31.67
7	32.11	31.88	31.47	36.20	30.65	29.91
8	30.78	34.79	33.43	30.09	30.65	29.47
9	27.56	27.60	21.76	26.11	33.24	28.95
10	22.67	20.52	17.84	22.78	19.35	29.12
Average for Periods 1-10	<b>33.77</b>	<b>34.98</b>	<b>31.36</b>	<b>33.70</b>	<b>32.48</b>	<b>35.92</b>
11	39.00	43.65	27.45	48.06	33.06	37.11
12	36.33	39.06	31.76	41.39	32.41	38.68
13	31.44	34.17	22.06	42.78	40.83	39.47
14	33.11	35.10	27.06	40.28	33.89	44.47
15	33.56	32.60	26.96	40.09	37.13	33.86
16	29.56	31.35	20.69	40.19	30.19	36.49
17	19.33	26.04	17.25	34.44	31.85	28.60
18	24.67	24.58	14.51	27.13	29.17	28.16
19	24.67	28.65	15.00	33.70	27.22	26.49
20	20.78	21.46	19.12	27.13	26.94	23.07
Average for Periods 11-20	<b>29.24</b>	<b>31.67</b>	<b>22.19</b>	<b>37.52</b>	<b>32.27</b>	<b>33.64</b>
21	63.33	59.48	56.18	67.96	56.02	55.00
22	66.44	61.35	60.29	67.22	45.74	53.25
23	66.67	60.83	59.90	68.43	48.33	53.68
24	65.56	61.04	56.96	69.91	51.85	47.89
25	68.89	63.85	60.98	66.94	45.28	44.12
26	66.11	64.79	54.61	66.11	47.50	47.19
27	67.11	60.63	56.96	67.22	38.24	39.12
28	64.11	56.77	55.00	62.78	42.87	42.02
29	66.89	51.25	51.37	54.07	37.96	41.84
30	52.44	38.96	43.14	51.02	32.13	28.51
Average for Periods 21-30	<b>64.76</b>	<b>57.90</b>	<b>55.54</b>	<b>64.17</b>	<b>44.59</b>	<b>45.26</b>

**Appendix E - Player Type Adjustment Effects Logit Regressions for each Treatment**

Regression: Logit	Gains Frame				Loss Frame				Loss-and-Risk Frame			
	Full Cooperator (0/1)		Free Rider (0/1)		Full Cooperator (0/1)		Free Rider (0/1)		Full Cooperator (0/1)		Free Rider (0/1)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Independent Variables	Periods 1-10	Periods 11-20	Periods 1-10	Periods 11-20	Periods 1-10	Periods 11-20	Periods 1-10	Periods 11-20	Periods 1-10	Periods 11-20	Periods 1-10	Periods 11-20
Lagged others' contributions	0.0172 (0.0148)	0.0420*** (0.0137)	-0.0418*** (0.00941)	-0.0664*** (0.0117)	0.0179 (0.0121)	0.0630*** (0.0142)	-0.0443*** (0.00882)	-0.0691*** (0.00961)	0.0138 (0.0146)	0.0171 (0.0142)	-0.0517*** (0.00933)	-0.0454*** (0.0102)
Announcement (GCA)	0.451 (0.340)	-0.0922 (0.364)	-0.270 (0.235)	-0.0802 (0.276)	0.477 (0.359)	0.805** (0.379)	-0.251 (0.231)	-0.588** (0.237)	-0.252 (0.326)	-0.652 (0.424)	-0.0565 (0.222)	0.0469 (0.266)
Loss Aversion Index (LA)	0.0789 (0.166)	0.0436 (0.155)	-0.153* (0.0828)	-0.0882 (0.0992)	-0.0970 (0.109)	-0.0369 (0.122)	0.0463 (0.0631)	0.107 (0.0732)	0.0268 (0.104)	-0.0970 (0.134)	0.0202 (0.0627)	0.0881 (0.0844)
Risk Attitude	-0.0887 (0.0694)	0.0795 (0.0929)	0.0911 (0.0732)	0.0877 (0.0760)	0.000154 (0.0768)	0.223** (0.0964)	0.0836 (0.0624)	0.111* (0.0636)	0.0958 (0.0813)	0.190 (0.140)	0.0832 (0.0521)	0.0471 (0.0641)
Period	-0.110** (0.0518)	-0.0778 (0.0567)	0.106*** (0.0294)	0.145*** (0.0281)	-0.0914* (0.0468)	-0.105* (0.0565)	0.0877*** (0.0273)	0.0759*** (0.0251)	-0.0505 (0.0489)	0.00490 (0.0340)	0.104*** (0.0266)	0.0939*** (0.0208)
Constant	-2.343*** (0.813)	-2.392*** (0.924)	-1.422*** (0.518)	-2.905*** (0.708)	-2.131*** (0.765)	-2.438* (1.259)	-0.584 (0.579)	-0.868 (0.699)	-3.062*** (0.833)	-4.678*** (1.251)	-1.778*** (0.517)	-2.169*** (0.673)
Demographic Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	837	930	837	930	945	1,050	945	1,050	999	1,110	999	1,110
Wald chi <sup>2</sup>	40.66	24.84	47.28	73.22	23.08	53.75	69.28	83.35	18.85	11.28	98.43	58.10
Prob > chi <sup>2</sup>	0.0002	0.0362	0.0000	0.0000	0.0589	0.0000	0.0000	0.0000	0.1277	0.5873	0.0000	0.0000
Pseudo R <sup>2</sup>	0.0780	0.0612	0.0671	0.1211	0.0721	0.2174	0.0833	0.1466	0.0385	0.0581	0.0985	0.0692

Robust standard errors in parentheses  
 \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

**Appendix F - Likelihood of Reaching the Threshold in Period 30**

Independent Variables	Dependent Variable: Reached Threshold in Period 30 (0/1)		
	Gains Frame	Loss Frame	Loss and Risk Frame
Announcement	-1.882* (0.980)	1.543* (0.816)	0.729 (0.885)
Group Loss Aversion (LA) Index	-0.217 (0.176)	-0.284* (0.162)	0.164 (0.197)
Group Risk Attitude	0.369** (0.178)	-0.163 (0.106)	-0.0552 (0.0747)
Constant	-5.171* (2.669)	1.816 (1.845)	-0.694 (1.366)
Log pseudo-likelihood	-51.26	-62.68	-62.50
Observations	93	105	111
Wald chi <sup>2</sup>	5.94	7.47	1.45
Prob > chi <sup>2</sup>	0.1144	0.0583	0.6931
Pseudo R <sup>2</sup>	0.1896	0.1383	0.0351

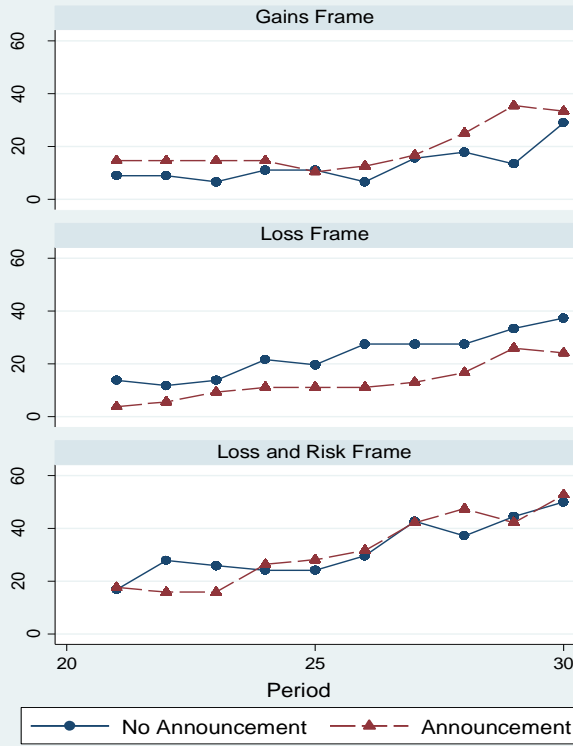
Robust Standard errors clustered at the Group-Level in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1



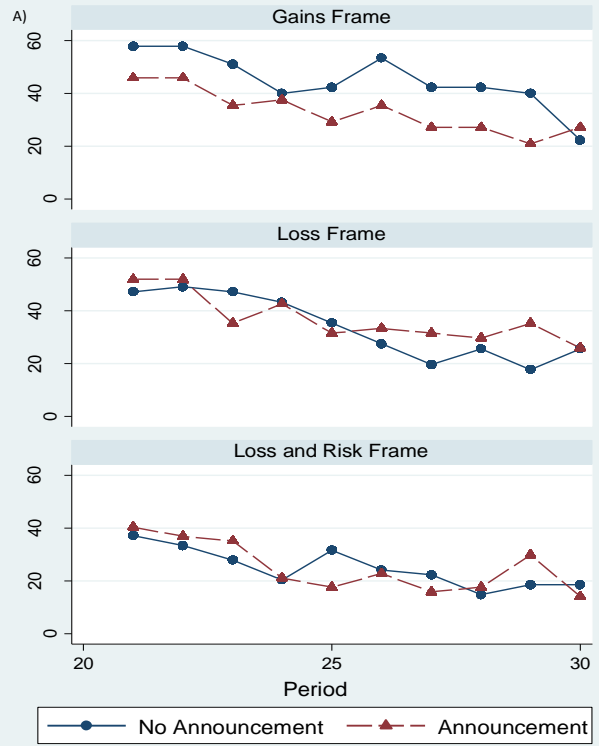
## Appendix G Evolution of Player Types in periods 21-30

A) Evolution of Free-Riders in Periods 21-30



Graphs by Frame

B) Evolution of Fair sharers in Periods 21-30



Graphs by Frame

C) Evolution of Altruists in Periods 21-30



Graphs by Frame

**Appendix H – Gains Frame: Likelihood of Player Type in periods 21-30**

Independent Variables	(1) Free-rider (0/1)	(2) Fair-sharer (0/1)	(3) Altruist (0/1)
Lagged Sum of Contributions	-0.0848*** (0.0145)	0.0420*** (0.0111)	0.0253*** (0.00770)
Announcement	0.277 (0.391)	-0.527 (0.324)	0.000995 (0.290)
Loss Aversion Index (LA)	0.133 (0.152)	-0.138 (0.116)	0.0758 (0.106)
Risk Attitude	-0.166 (0.152)	0.0396 (0.0778)	0.143** (0.0667)
Period	0.223*** (0.0453)	-0.171*** (0.0284)	0.0439 (0.0345)
Constant	-5.006*** (1.493)	3.608*** (0.952)	-4.204*** (0.954)
Demographic Control Variables	Yes	Yes	Yes
Log pseudo-likelihood	-316.567	-554.463	-492.506
Observations	930	930	930
Wald chi <sup>2</sup>	75.33	55.70	31.01
Prob > chi <sup>2</sup>	0.0000	0.0000	0.0055
Pseudo R <sup>2</sup>	0.2295	0.1074	0.0651

Robust standard errors in parentheses  
 \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

**Appendix I – Loss Frame: Likelihood of Player Type in periods 21-30**

Independent Variables	(1) Free-rider (0/1)	(2) Fair-sharer (0/1)	(3) Altruist (0/1)
Lagged Sum of Contributions	-0.117*** (0.0149)	0.0368*** (0.00772)	0.0610*** (0.0115)
Announcement	-0.585 (0.386)	0.0893 (0.299)	0.466 (0.310)
Loss Aversion Index (LA)	-0.0982 (0.125)	-0.0490 (0.0935)	-0.105 (0.0957)
Risk Attitude	0.0170 (0.0861)	-0.163** (0.0698)	0.0271 (0.0678)
Period	0.293*** (0.0415)	-0.179*** (0.0243)	0.0243 (0.0320)
Constant	-4.283*** (1.386)	2.964*** (0.880)	-3.742*** (1.076)
Demographic Control Variables	Yes	Yes	Yes
Log pseudo-likelihood	-295.469	-612.065	-525.095
Observations	1050	1050	1050
Wald chi <sup>2</sup>	122.50	81.02	57.96
Prob > chi <sup>2</sup>	0.0000	0.0000	0.0000
Pseudo R <sup>2</sup>	0.4049	0.1025	0.1227

Robust standard errors in parentheses  
 \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

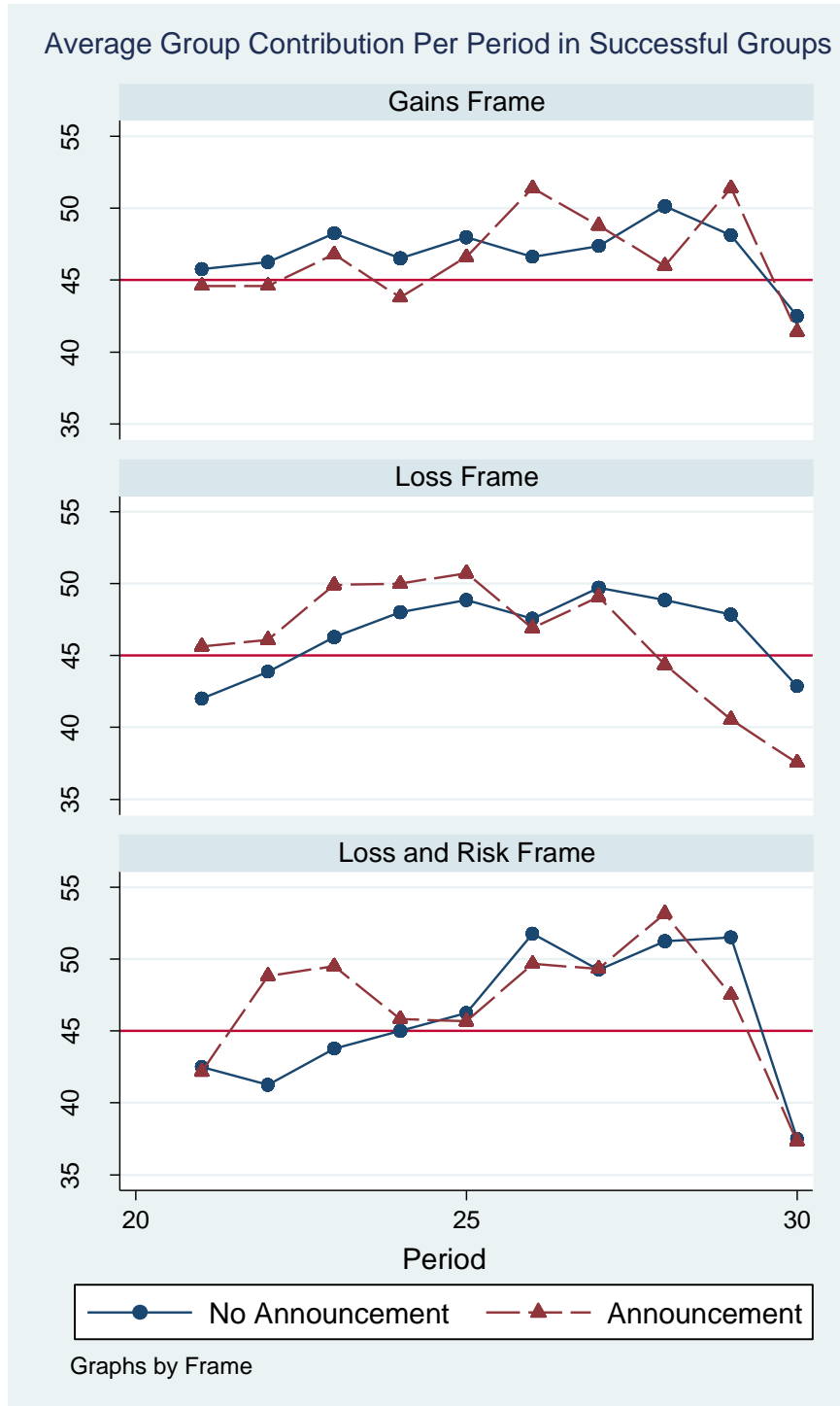
**Appendix J – Loss and Risk Frame: Likelihood of Player Type in periods 21-30**

Independent Variables	(1) Free-rider (0/1)	(2) Fair-sharer (0/1)	(3) Altruist (0/1)
Lagged Sum of Contributions	-0.0847*** (0.00928)	0.0461*** (0.0101)	0.0657*** (0.0126)
Announcement	0.207 (0.333)	0.0382 (0.324)	-0.358 (0.339)
Loss Aversion Index (LA)	0.206* (0.106)	0.119 (0.101)	-0.258*** (0.0992)
Risk Attitude	-0.0390 (0.0771)	-0.00755 (0.0786)	0.0892 (0.0777)
Period	0.209*** (0.0317)	-0.147*** (0.0297)	7.19e-05 (0.0321)
Constant	-5.057*** (1.136)	1.338 (1.099)	-3.160*** (1.053)
Demographic Control Variables	Yes	Yes	Yes
Log pseudo-likelihood	-515.31	-543.93	-449.63
Observations	1,100	1,100	1,100
Wald chi <sup>2</sup>	127.2	67.91	59.08
Prob > chi <sup>2</sup>	0.0000	0.0000	0.0000
Pseudo R <sup>2</sup>	0.2559	0.1078	0.1278

Robust standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

**Appendix K – Average Group Contribution per period for Groups Successful in Reaching the Threshold, by Frame.**



### Appendix L Player Likelihoods in all four treatments in the Gains and Loss Frames during the TPG game

Regression: Logi	Free Rider (0/1)				Fair Sharer (0/1)				Altruist (0/1)			
	Gains Frame		Loss Frame		Gains Frame		Loss Frame		Gains Frame		Loss Frame	
Independent Variable	(1) GCN	(2) GCA	(3) LCN	(4) LCA	(5) GCN	(6) GCA	(7) LCN	(8) LCA	(9) GCN	(10) GCA	(11) LCN	(12) LCA
Lagged Sum of Contributions	-0.124*** (0.0177)	-0.0638*** (0.0184)	-0.118*** (0.0222)	-0.124*** (0.0179)	0.0519*** (0.0140)	0.0323*** (0.0118)	0.0484*** (0.0129)	0.0262*** (0.00928)	0.0200 (0.0141)	0.0170* (0.0103)	0.0602*** (0.0181)	0.0638*** (0.0167)
Loss Aversion (LA) index	0.157 (0.110)	0.196 (0.222)	-0.108 (0.174)	0.0195 (0.131)	-0.207 (0.140)	0.0690 (0.223)	-0.101 (0.128)	-0.0150 (0.126)	0.366** (0.162)	-0.340** (0.160)	0.121 (0.156)	-0.267** (0.114)
Risk Attitude	-0.264** (0.129)	-0.160 (0.246)	-0.0442 (0.117)	-0.0260 (0.114)	0.113 (0.102)	-0.0789 (0.119)	-0.159 (0.112)	-0.192* (0.0995)	0.112 (0.0812)	0.218** (0.108)	-0.0622 (0.0892)	0.0801 (0.0948)
Period	0.318*** (0.0769)	0.194*** (0.0570)	0.323*** (0.0605)	0.313*** (0.0635)	-0.204*** (0.0507)	-0.168*** (0.0347)	-0.260*** (0.0421)	-0.147*** (0.0323)	0.0967 (0.0627)	0.0107 (0.0425)	0.111** (0.0437)	-0.0335 (0.0463)
Constant	-6.227*** (2.120)	-5.987** (2.388)	-4.429** (1.819)	-5.112** (2.164)	3.742*** (1.325)	4.836*** (1.368)	3.638** (1.517)	2.851** (1.206)	-5.095*** (1.672)	-4.374*** (1.303)	-6.182*** (1.511)	-1.264 (1.547)
Demographic Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	450	460	450	490	450	480	510	540	450	480	510	540
Wald chi <sup>2</sup>	78.21	39.31	112.5	119.0	47.07	53.53	85.10	60.72	31.11	31.58	46.50	40.84
Prob > chi <sup>2</sup>	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0032	0.0028	0.0000	0.0001
Pseudo R <sup>2</sup>	0.3433	0.2202	0.4375	0.4008	0.1641	0.1685	0.2052	0.1493	0.1214	0.1215	0.1822	0.1508

Robust standard errors, clustered at the individual level, in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1