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Cooperation and Climate Change

Can Communication Facilitate the Provision of Public Goods in Heterogeneous Settings?

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Cooperation and Climate Change: Can Communication Facilitate the Provision of Public Goods in Heterogeneous Settings?

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Abstract

International and domestic efforts to reduce greenhouse gas emissions require a coordinated effort from heterogeneous actors. This experiment uses a public good game with a climate change framing to consider whether cooperation is possible in just such a climate change context. Specifically, we examine whether groups of heterogeneous individuals can meet a collective emissions reduction target through individual contributions. Participants represent two different sectors of society with differing marginal costs of abatement. Thus, the equity considerations that make climate change such a contentious issue are implicit in the experiment framing. Subjects are able to communicate with one another in order to coordinate contribution strategies. The results indicate that participatory processes and stakeholder engagement play an important role in promoting cooperation—even when heterogeneity is present. However, heterogeneity makes it more difficult for groups to reach consensus on how to distribute an abatement burden. Further, the non-binding nature of the agreement results in significant levels of free-riding. In addition, heterogeneity appears to provide disadvantaged player-types with a justification for free-riding. Ultimately, the results indicate that participatory processes alone are not sufficient to induce widespread compliance with a mitigation obligation.

Key Words: public good, framing, communication, heterogeneity, emissions reduction target

JEL Codes: H41, Q54, Q58

Contents

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Introduction

To reduce the risk of catastrophic climate change, a significant reduction in global greenhouse gas emissions is needed. Herein lies the heart of the public good dilemma synonymous with climate change: while all countries (individuals) are affected by climate change and contribute to it, no one country (individual) can solve the problem in isolation. Furthermore, while mitigation entails a private cost, the benefits of mitigation are shared equally by all countries (individuals), creating an incentive to free-ride (Brekke and Johansson-Stenman 2008). As no one country (individual) can sufficiently provide the public good, multilateral negotiations are needed to sustain cooperative behaviour. However, while multilateral climate negotiations, such as the United Nations Framework Convention on Climate Change (UNFCCC), and international environmental agreements, such as the Kyoto Protocol, act as mechanisms for cooperation, they have failed to induce widespread cooperation because of heterogeneity. Parties to these negotiations are heterogeneous in income and historical responsibility, amongst other things, and it is these disparities which shape the discussions of how to distribute both the abatement burden and future entitlement to emissions. The experiment reported here considers whether cooperation is possible in a climate change context. Specifically, using a public good game with a climate change framing, we examine whether groups of heterogeneous individuals can meet a collective emission reduction target through individual contributions. Subjects are able to communicate with one another in order to determine how to distribute the abatement burden. Whereas the experimental evidence from public good games with homogeneous subjects indicates that communication alone significantly improves cooperation, the results from this experiment indicate that, in a context where participants are heterogeneous, communication alone does not adequately facilitate public good provision. The

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results indicate that, while stakeholder participation plays an important role in climate policy formulation, participatory processes alone are not sufficient to induce widespread compliance with a mitigation obligation.

Climate change context

While the United Nations climate talks are a mechanism for global cooperation, climate diplomacy has at present been stalled by conflicts over the future of the Kyoto Protocol, the architecture of a future climate regime, uncertainty around the participation of the United States and the degree of differential treatment between developed countries and large emerging economies such as China and India (Saran 2010; Winkler and Beaumont 2010; Rajamani 2010).

In a national context, stakeholder participation in domestic policy making processes is equally divisive amid party politics, special interest lobbying, alternative developmental priorities and concerns relating to social and distributive justice. The United States, the world's second largest emitter (in terms of current emission levels), has repeatedly failed to pass national climate legislation amid bitter partisanship and the contention that emission reduction can only be achieved at a cost to economic growth, given the economy's reliance on livestock production, coal mining and the oil and gas industries.

A key characteristic of multilateralism and stakeholder participation in policy processes is that a degree of heterogeneity exists amongst the participants. This is especially true in a climate change context where successfully reducing greenhouse gas emissions requires cooperation from multiple players who are asymmetric. On a global scale, international environmental agreements such as the Kyoto Protocol require countries with divergent levels of income and historical responsibility to agree on how best to distribute an abatement burden and divvy up future entitlements to emissions. On a national scale, firms and individuals with varied levels of income, energy usage, abatement costs and mitigation capacities must do the same.

Framing

As climate change mitigation is such a polarizing topic, the experiment reported here considers the scope for cooperation using a public good game with a climate change context, where the experiment instructions are framed as two sectors of society deciding how to distribute an emission reduction target. While the emission reduction target (as per the framing) was not binding in the treatments discussed in this paper, it was emphasised.

Various studies have shown that adding context (framing) to experimental instructions significantly alters the results (Eckel and Grossman 1996; Lieberman et al. 2004; Burnham et al. 2000). Eckel and Grossman (1996) use a double-anonymous dictator game but frame the instructions by replacing the anonymous recipient with a well-known charity. Altruistic giving is significantly increased. Lieberman et al. (2004) conduct a repeated public good game with undergraduate students and Israeli pilots. The game is labeled as the Wall Street Game for half the participants and the Community Game for the other half. Cooperation was significantly less in the Wall Street Game. In a two-person trust game, Burnham et al. (2000) substitute either the word ―partner” or ―opponent” into the instructions. Across pooled data, the authors find partners are significantly more trusting than opponents.

These studies indicate that experimental results can be affected by context. Eckel and Grossman (1996) argue that, in order to introduce the social and psychological factors that affect economic decision making, abstraction needs to be abandoned to some extent. Lowenstein (1999) argues that the external validity of experimental results can be enhanced when appropriate context is added.

In contrast to the previous studies, Abbink and Schmidt (2006) compare context-free and in-context instructions in a bribery experiment. Unlike the previous studies, they find no significant difference between the two frames. The authors argue that, as the neutral version of the experiment adequately conveys the essential features of a bribery situation, framing the instructions does not add to the subjects' interpretation of the game.

However, when it comes to the real-world climate change context, individuals are extremely divided on who bears the responsibility of reducing emissions, which policy instruments would be most effective (carbon tax or emission trading scheme for example) and who should bear the cost of mitigation (the consumer or producer). In addition, climate change discourses become extremely emotionally charged and clouded by issues of social and distributive justice. In the United States, support for climate change legislation even has a political dimension as the Democratic Party is associated with being pro-climate legislation while Republicans are considered to be opponents.

In this context, unlike the Abbink and Schmidt (2006) study, completely abstract terminology would not adequately encapsulate all the dimensions of the real-life context. While we do not claim that our framing successfully encapsulates all these dimensions, it does enable subjects to draw on their own subjective perceptions about climate mitigation when deciding on their contribution strategy.

As will be discussed, the instructions refer to subjects as capital (firms) and labour (households). Subjects are merely told that these classifications represent different sectors of society with different abatement costs and that they must decide as a group how to reduce emissions. We do not make any judgments about capital or labour in the text – for example that capital is “dirty” and is responsible for a greater proportion of emissions relative to labour or that, according to income and historical responsibility, capital should be responsible for the bulk of emission reduction. All the wording in the instructions beyond the framing of reducing an emissions inventory is very neutral.

As it happens, subjects had clear attitudes about climate change (appendix A). Specifically, 77% of subjects feel that firms should definitely be obligated to meet emission reduction targets, while only 15% feel that households should definitely be obligated to meet emission reduction targets.

Heterogeneity

As previously mentioned, heterogeneity is a key characteristic of climate talks. Whereas the evidence from public good games with homogenous players shows that players make positive but suboptimal contributions to public good provision (Ledyard 1995; Cherry et al. 2005; Gächter and Herrmann 2009), the effect of heterogeneity on cooperation is not fully clear from the literature. Heterogeneity has been introduced in the public good literature in a variety of ways. The effect of income heterogeneity on contributions has been examined by varying subjects’ endowments: the results of such studies are mixed. Some authors find endowment asymmetry increases cooperation (Chan et al. 1996, 1999; Buckley and Croson, 2006), and others conclude that cooperation is diminished (Anderson et al. 2008, Cherry et al. 2005). Heterogeneity has also been introduced by varying players’ impacts on either the public or private accounts: Palfrey and Prisbrey (1997) assign subjects different rates of return for their private accounts and find that the greater the return to the private good, and the higher the opportunity cost of public contribution, the lower the cooperation rates. Fisher et al. (1995) examine heterogeneity by varying the marginal per capita return (MPCR) within groups. They find that high-MPCR players contribute more to public good provision relative to low-MPCR players.

Framed Public Good Games

The majority of public good games framed in a climate change context do not incorporate within-group heterogeneity into the framing. Milinski et al. (2006) design a public good game where public good contributions are used to fund an advertisement about climate change in a daily newspaper. The authors include anonymous and non-anonymous treatments in their design and test whether knowledge affects behaviour by giving some groups additional information about climate change. The authors find that cooperation is highest in non-anonymous treatments and that additionally-informed participants are more cooperative. Milinski et al. (2008) design a threshold public good game where failing to reach the threshold is interpreted as failing to prevent catastrophic climate change. Participants can mitigate emissions by contributing varying amounts to a climate account. In the event that the threshold is reached, participants keep the remainder of their endowment not spent on mitigation; in the event that the threshold is not met, the authors vary the probability that a portion of their remaining endowment is lost. The authors find that groups facing a higher probability of losing their savings are more successful in meeting the collective target. Hasson et al. (2010) examine the trade-off between mitigation and adaptation by extending a one-shot public goods game with the introduction of a stochastic term to represent the probability of disaster from climate change. The authors vary the probability of disaster across treatments. The authors find contribution levels to be lower than those of comparable studies and, unlike Milinski et al. (2008), find no significant difference in the level of cooperation (mitigation) from varying probabilities of disaster.

Tavoni et al. (2011) do incorporate within-group heterogeneity into a repeated framed public good game, to examine how inherited inequality affects coordination in meeting a reduction target. In the event the target is not met, players face a 50% probability of losing the funds in their private accounts. Following the design of Milinski et al. (2008), all players are endowed with €40 and could invest €0, €2 or €4 in mitigation per round. During the first three rounds of the game, contributions are randomly determined: in the symmetric treatment, all players contribute €2; in the asymmetric treatment, half the group contributes €0 per round while the other half contributes €4. Thus, in the asymmetric treatment, rich and poor players enter the fourth round with €40 and €28, respectively. A smaller portion of groups met the threshold in the asymmetric treatment. With the introduction of communication, where players are able to make non-binding pledges, the proportion of asymmetric groups meeting the threshold triples and does not differ significantly from the number of symmetric groups meeting the target.

The experiment reported here uses a climate change framing to consider whether groups of heterogeneous individuals can meet a collective emission reduction target through individual contributions. In a series of one-shot public good games, participants must decide how to allocate their endowment between mitigation (public account) and business-as-usual (private account). Participants are urged to meet a non-binding national emission reduction target. Heterogeneity is introduced into the experiment by varying players' marginal abatement costs (the cost of reducing an additional unit of emissions).Players are able to communicate in order to coordinate meeting the target.

Communication

There is a large literature concerning the role of communication in both one-shot and repeated social dilemma experiments with homogeneous players, with the experimental evidence suggesting that communication alone significantly improves cooperation (Bochet et al. 2006; Brosig et al. 2003; Charness and Dufwenberg 2006; Ostrom 1992,1998; for reviews, see Ledyard 1995; Sally 1995; Gächter and Herrmann 2009).

However, Isaac and Walker (1988) indicate that the effectiveness of communication in facilitating cooperation declines as the choice environment becomes more complex – with the introduction of asymmetric endowments, for example. In a climate change context, the choice environment is certainly made more complex by the presence of heterogeneity – which, in climate change dialogues, is often synonymous with ―inequality". Examples of such heterogeneity/inequalities include the legacy of historical responsibility and differing marginal abatement costs and levels of wealth. The experiment framing ensures that this association of heterogeneity with inequality is implicit in the game. In this context, we include a communication treatment in this experiment and consider its role on cooperation within the climate change frame.

Results

Our results indicate that, while communication does improve cooperation, it does not adequately facilitate public good provision. Furthermore, the fact that communication results in two dominant contribution strategies of free-riding and perfect cooperation means that stakeholder engagement would be far more successful if the outcomes of participatory processes were binding. Finally, we conclude that this association of ―heterogeneity" with ―inequality" results in the disadvantaged player-type feeling justified in free-riding.

Ultimately, our results indicate that participatory processes alone are not sufficient to induce widespread compliance with a mitigation obligation.

The paper proceeds as follows: The experimental design is presented in the following section. The results are discussed next. The paper concludes with a discussion of policy implications.

Experiment

Sample

The experiment was conducted with 204 students recruited from the University of Cape Town (UCT), South Africa.

A summary of sample statistics is provided in Table 1. On average, subjects were 21 years old. Over 60% of subjects were male. Around 30% of subjects' classified their family's financial situation as lower income, while 67% classified their family as middle income. Students from a broad spectrum of faculties, including commerce, humanities, and engineering, were targeted for participation.

Table 1. Sample statistics

	Subjects n=204
Gender	
Male	0.63
Female	0.37
Race	
Black	0.78
Coloured	0.07
Indian	0.05
White	0.07
Other	0.02
Schooling	
Public	0.65
Private	0.35
Nationality	
South African	0.69
Other	0.31
Age	20.92
	(1.76)
Household size	5.56
	(2.55)
Family's financial situation	
Upper income	0.05
Middle income	0.67
Lower income	0.28

Note: Standard deviations in parenthesis

Design

Thirty-four groups of four students each participated in a series of one-shot linear public good games. The public good games were framed in terms of climate change mitigation. Subjects had to allocate their endowment of ten experimental currency units (ECUs) between mitigation (public account) and business-as-usual (private account). While participants were urged to meet a national emission reduction target, this target was not binding in the baseline and communication treatments. Heterogeneity was introduced by varying players' marginal costs of abatement. Within each group, two players were allocated a low marginal cost of abatement and two players were allocated a high marginal cost of abatement.

The payoff functions for both the low-MCA player (π_l) and high-MCA player (π_h) are provided below:

$$\pi_{l_i} = 12 \times (10 - C_{l_i}) + 0.25 \sum_{i=1}^{2} (20 \times C_{l_i}) + (10 \times C_{h_i}) \quad (1)$$

$$\pi_{h_i} = 6 \times (10 - C_{h_i}) + 0.25 \sum_{i=1}^{2} (20 \times C_{l_i}) + (10 \times C_{h_i}) \quad (2)$$

where C_l and C_h signify investment in mitigation (public account) by low-MCA players and high-MCA players, respectively.

A player with a low marginal cost of abatement was able to reduce more emissions with one ECU relative to a player with a high marginal cost of abatement. This is reflected in the players' payoff functions as asymmetric marginal contributions to the public account. Specifically, every ECU contributed toward mitigation (public account) by low-MCA and high-MCA players was multiplied by a factor of 20 and 10, respectively (equations 1 and 2).

Note that the accumulated total of ECUs in the public account (after being multiplied by the relevant factor of 20 or 10) denotes the emission reduction of the group. Appendix B illustrates emission reductions, by player-type, per token investment in the public good.

Participants were told that government has set a national emission reduction target of 140 units. This target could be met through low and high-MCA player-types contributing different combinations of ECUs to the public account (appendix B).[1] Note that, although players were

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[1] As will be discussed in the following sub-section, the experiment included two tax treatments, which are not discussed here. The significance of the total of 240 for the target becomes clear in the tax treatments. In the first tax scenario, both player-types must reduce their emissions equally, irrespective of the difference in the cost of abatement. As such, all four players in a group must reduce emissions by 60 units each. In the second tax scenario,

urged to meet the target, the target was not binding in the baseline and communication treatments.

Players earned a return from investing in mitigation (public account). On a global scale, as we assume a country's national abatement target to be part of a multilateral commitment (such as the Kyoto Protocol), returns to mitigation quantified the benefits of reduced likelihood of dangerous climate change, such as an extreme weather event. On a national scale, the returns quantified reduced pressure on the grid as mitigation is translated into a reduction in electricity usage.

As everyone benefits equally from mitigation and no one is excluded from these benefits, the accumulated total of ECUs in the public account were distributed equally among the four group members, irrespective of individual contribution. As such, one ECU invested in mitigation by a low-MCA player generated a return of five ECUs for each group member. Similarly, one ECU invested in mitigation by a high-MCA player generated a return of 2.5 tokens for each group member.

Contributions to the private account represented investments in other private income-generating activities (or business-as-usual). Equations 1 and 2 indicate that each ECU contributed to the private account generated a private return of 12 and 6 tokens for low-MCA and high-MCA players, respectively.[2] As such, the marginal per capita return, which is the ratio between the marginal value of a token invested in the public account and the marginal value of a token invested in the private account, was 0.42, the same for both player-types – again indicating that everyone derives the same benefits from mitigation.

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both player-types can reduce emissions by different quantities as long as they contribute the same amount in ECUs. If each player contributes four tokens, each group will collectively meet the emission reduction target but low-MCA players will be reducing emissions by 80 units each, while high-MCA players will be reducing emissions by 40 units each.

[2] In the instructions, participants were told that low-MCA players represent capital (firms) and that high-MCA players represent labour (households). This distinction is for illustrative purposes, as the experiment design is applicable in any context where marginal abatement costs differ (for example two firms or two households). Participants were told that the private account represents investment opportunities other than mitigation. Because capital can more easily invest in productive (income-generating) activities, as compared to labour, capital generates a higher return from money invested in the private account. As such, capital (low-MCA player-type) contributions to the private account generate a return of 12 as compared to a return of 6 for labour (high-MCA player-type).

The Nash-equilibrium for all players was to contribute nothing toward mitigation, while the social optimum was reached when all players in the group contribute their entire endowment to mitigation.

Procedures

Participants were recruited through an advertisement which was emailed to students as well as being posted on various student networking sites. In addition, a number of students were reached through word of mouth and announcements in lecture theatres.

Upon entering the lab, participants were randomly allocated an experiment number and a factor of production (capital or labour). Given the random allocation, it is evident that capital did not —earn” his/her higher marginal contribution.

Participants were given a R20 show-up fee and informed that the game consisted of five phases during which they would be playing for actual money. A conversion rate of 1 ECU to 0.25 South African Rands was specified in advance. Participants were also advised that they would be asked to answer a questionnaire at the end of the experiment. The anonymity of their responses throughout the duration of the experiment was emphasised.

The full list of treatments and phases are outlined in Table 2. The experiment consisted of three treatments. Treatment 1 merely consisted of the baseline treatments and acts as a control. Treatments 2 and 3 consisted of baseline, communication and tax treatments, and differed only in the ordering of the treatments. At the end of the day, in treatments 2 and 3, subjects were asked to vote on which game they would like to play again as the final game of the day. Before making their decisions, roughly half the participants in each treatment were provided with payoff feed-back for each treatment.

This paper reports the results of the baseline and communication games only (reflected in bold in Table 2). The tax games are discussed in Brick and Visser (2010) while the voting treatment is yet to be analysed.

Table 2. Experiment summary

	Treatment 1		Treatment 2		Treatment 3	
	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2
	n=36	*n=32*	*n=32*	*n=36*	*n=36*	*n=32*
Phase 1	$Baseline_1$	$Baseline_1$	Baseline	Baseline	Baseline	Baseline
Phase 2	$Baseline_2$	$Baseline_2$	Comm.	Comm.	Tax44	Tax44
Phase 3	$Baseline_3$	$Baseline_3$	Tax36	Tax36	Tax36	Tax36
Phase 4	$Baseline_4$	$Baseline_4$	Tax44	Tax44	Comm.	Comm.
Feed-back	No	No	Yes	No	Yes	No
Vote	No	No	Yes	Yes	Yes	Yes
Phase 5	$Baseline_5$	$Baseline_5$	Tax44	Tax44	Comm.	Comm.

The communication treatment is identical to the baseline treatment except that, before contributing to the public account, group members are allowed to participate in costless online communication. During the online chat, players are provided with pseudonyms and individual identities remain anonymous. At the end of the discussion, the group members take a non-binding vote regarding each player-type's contribution. Note that the payoff structure remains the same for both treatments. Players are aware of the payoff functions of both player-types.

The experiment instructions for the baseline and communication treatments are provided in appendix C.

The experiments were run over a week with one treatment taking place per day. Each treatment lasted approximately 2-3 hours (including payment).

There were four envelopes at each computer terminal, containing a summary sheet and set of instructions for the first four phases of the game.[3] Subjects were also provided with a payoff table showing the payoff for each player type given their contributions and the contributions of the other players. Subjects were provided with a number of worked examples. Excel-based calculators reflecting the payoffs for each player-type were made available to the participants in an effort to lighten their cognitive load.

[3] Envelopes were used to emphasise the one shot nature of the games: as a new envelope was opened, it was emphasised that participants were now in a new experiment.

During each treatment, subjects would enter their contribution on a decision sheet. These were collected by invigilators so that the enumerator could calculate the group's total contribution and thus individual earnings.

After each phase, groups were reassigned so that no person was in the same group twice.[4]

Finally, while participants waited to receive payment, they were asked to fill in a short questionnaire which requested demographic information and attempted to gauge attitudes towards climate change (appendix A illustrates some of these attitudes).

The instructions were read aloud by the experimenter while the subjects followed on their own hard copies.

While the experiment had a climate change framing, the instructions were neutrally worded in relation to issues around distributive justice: words such as equity, equality and fair were never referenced.

Subjects were never made aware of their group members' individual contributions.

Results

Mann-Whitney tests confirm there to be no significant difference in the distribution of the baseline treatments ($p = 0.1624$) and the communication treatments ($p = 0.1273$) in session 1 and session 2 in treatments 2 and 3. Therefore, like treatments in these sequences have been pooled (Table 3).

Baseline

Average Contributions

Observation 1: Participants make voluntary but suboptimal contributions to public good provision.

Observation 2: Contributions do not significantly differ by player-type.

Climate change epitomizes the public good dilemma of acting in one's own interest versus acting in the interest of the collective. While the dominant strategy in a linear public good game is for each player to free-ride, as is evident from Table 3, average contributions (across

[4] The exception is that, if subjects voted for communication in the final phase, participants would be assigned to the same group as in the exogenous communication phase.

player-types): (i) range between 17.9% and 31.2% in the four baseline games in treatment 1 and (ii) average 32.1% in pooled treatment 2 & 3. These contributions are consistent with evidence from the lab which suggests that people make positive but suboptimal contributions to public good provision (Ledyard 1995; Cherry et al. 2005; Gächter and Herrmann 2009). In a climate change context, instances of voluntary but suboptimal mitigation are evident, for example, in the participation of some nations in the Kyoto Protocol and the enactment of renewable portfolio initiatives in certain U.S. states. At the individual level, people voluntarily reduce energy consumption, invest in energy saving technologies (such as solar panels and solar water heaters) and support producers who have taken steps to reduce their carbon footprint.

Table 3. Average contributions

	Treatment 1				Treatment 2 & 3 (pooled)		
	Avg. *n=68*	Low-MCA *n=34*	High-MCA *n=34*		Avg. *n=136*	Low-MCA *n=68*	High-MCA *n=68*
Baseline 1	2.90 (2.93)	2.68 (2.73)	3.12 (3.14)	Baseline	3.21 (2.90)	3.43 (2.84)	2.99 (2.96)
Baseline 2	2.32 (2.85)	1.79 (2.59)	2.85 (3.03)	Comm.	4.44 (4.23)	4.75 (4.08)	4.13 (4.38)
Baseline 3	2.18 (2.78)	2.26 (2.55)	2.09 (3.03)				
Baseline 4	2.35 (2.76)	2.38 (2.90)	2.32 (2.66)				

Notes: Participants were provided with an endowment of ten experimental currency units at the start of each game. See appendix D for average contributions for treatments 2 and 3, separately.

However, the contribution levels in Table 3 are lower than those found in the literature, where contributions to public good provision in one-shot public good games typically average between 40% and 60% of endowments.

The low contribution rates are likely driven by the high return from investing in business-as-usual (private account) relative to investing in mitigation (public account), which is in line with the real-world returns to mitigation. The experimental evidence shows that contributions are higher the higher the marginal return from investing in the public account (Gächter and Herrmann 2009). In our experiment design, an ECU invested in mitigation by a low-MCA player (high-MCA player) generates a return of 5 (2.5) ECUs relative to a return of 12 (6) for an ECU invested in the private account. This conflict epitomises the climate change dilemma, where individual returns on mitigation, particularly in the short term, are extremely low. The contribution levels in Table 3 are more in line with the climate-change-framed public good game of Hasson et al. (2010), where contribution rates averaged 26.5% amid a similarly low MPCR of 0.368.

When comparing average contribution rates, Mann-Whitney tests indicate there to be no significant difference between the contributions of low and high-MCA players in the four baseline games in treatment 1 as well as the baseline game in pooled treatments 2 & 3 ($p > 0.080$ for all treatments). The implication is that investment in mitigation does not differ according to marginal abatement costs, but that other motives are driving cooperation. Ruben and Reidl (2009) similarly find that, when the opportunity to punish is absent, heterogeneity does not matter and, furthermore, that the dominant contribution norm is that of free-riding.

The Distribution of Contributions to Mitigation

Observation 3: Free-riding is the dominant contribution norm for both player-types.

An examination of individual (as opposed to mean) contribution rates reveals that the dominant contribution strategy for both players is to free-ride (contribute nothing toward public good provision).

Table 3 depicts the frequency of contributions of zero to ten ECUs to public good provision for the baseline games in treatment 1 and treatments 2 & 3 (pooled).

It is evident from Table 3 that free-riding is the dominant contribution strategy for both player-types: in all the baseline games, binomial tests indicate that the proportion of contributions of zero tokens significantly differs from the proportion of contributions at all other contribution levels at the 5% level.

Table 3. Frequency distribution of contributions to the public good in the baseline treatment

	Contribution										
	0	1	2	3	4	5	6	7	8	9	10
Treatment 1											
Low-MCA player-type (n=34)											
Baseline 1	*0.324*	0.029	0.177	0.206	0.059	0.088	0.000	0.029	0.029	0.029	0.029
Baseline 2	*0.529*	0.118	0.059	0.059	0.088	0.000	0.088	0.000	0.029	0.029	0.000
Baseline 3	*0.353*	0.147	0.147	0.118	0.029	0.059	0.029	0.059	0.059	0.000	0.000
Baseline 4	*0.382*	0.147	0.088	0.118	0.059	0.059	0.059	0.000	0.029	0.000	0.059
High-MCA player-type (n=34)											
Baseline 1	*0.294*	0.088	0.118	0.088	0.177	0.059	0.029	0.000	0.059	0.000	0.088
Baseline 2	*0.324*	0.088	0.147	0.059	0.147	0.059	0.088	0.000	0.000	0.000	0.088
Baseline 3	*0.500*	0.088	0.177	0.000	0.029	0.029	0.029	0.088	0.000	0.000	0.059
Baseline 4	*0.353*	0.177	0.088	0.118	0.059	0.029	0.088	0.059	0.000	0.000	0.029
Treatment 2 & 3 (pooled)											
Low-MCA player-type (n=34)											
Baseline	*0.206*	0.103	0.059	0.191	0.162	0.074	0.059	0.029	0.059	0.000	0.059
High-MCA player-type (n=34)											
Baseline	*0.338*	0.074	0.088	0.059	0.132	0.132	0.074	0.015	0.029	0.000	0.059

The results from the baseline games indicate that, while there is a degree of voluntary cooperation, there is a significant amount of free-riding. Likewise, in a climate change context, not all developed and large emerging economies are signatories to the Kyoto Protocol and, on a domestic level, not all individuals take steps to reduce their carbon footprints. It is evident that a mechanism is needed to induce widespread cooperation.

As communication has been shown to significantly improve cooperation in homogeneous public good games, pre-play communication is introduced. In doing so, our aim is also to simulate stakeholder participation in line with bottom-up approaches that incorporate a pledge-and-review approach to reducing emissions. In such an approach, countries individually determine their mitigation objectives, which collectively become the global emission reduction target. Determining a national reduction target requires engagement from different sectors of society.

Communication (treatments 2 & 3 pooled)

Observation 4: Heterogeneity increases the difficulty of reaching consensus on a contribution strategy.

Observation 5: A contribution strategy of equality of earnings is supported by the majority of participants and is the consensus reached by the majority of groups.

In the communication phase, subjects were able to chat online in order to discuss a group contribution strategy.

In public good games with homogeneous players, not only do participants typically favour a contribution strategy of equal contributions, but they are willing to incur costly sanctioning to signal disapproval of group members who deviate from this strategy (Fehr and Gächter 2000, 2002; Fehr and Fischbacher 2004; Anderson and Putterman 2006; Gächter et al. 2008; Gächter and Herrmann 2009; Reuben and Riedl 2009). However, it is unclear as to what contribution norm will arise in a public good setting with heterogeneous players where a contribution strategy of ―equal contributions" will yield unequal incomes.

Three contribution strategies emerged from the online chat transcripts. The strategies advocated were derived from the fairness concepts of equality and equity (Konow 2003; Konow et al. 2009).

Equality of Income

In the public good game literature, equality is a concept of fairness that considers all participants as equals, regardless of individual capacity. Thus, in the experiment reported here, equality would make no distinction between low-MCA player-types and high-MCA player-types, even though the player-types differ in terms of their marginal abatement costs/marginal contributions to the public good.

The contribution strategy most frequently advocated by the participants was equality of income. To achieve equality of income, all players must contribute their full endowment to mitigation. In this case, the emissions target of 240 is exceeded and the social optimum is reached. This is reflected in the chat transcripts by players noting that ―the only fair thing to do is contribute all our income publicly", ―if we all go 10 then we force the system to distribute it equally amongst us" and ―think about it, if we all contribute 10 tokens then we each get a payoff of 150 tokens, which is much higher than if any of us were selfish".

Equality of Emissions Reduced

Another contribution strategy reflecting equality, but related to emissions reduction and contributions to the public account, advocates that high-MCA player-types (labour) contribute twice as many tokens to mitigation as their low-MCA (capital) counterparts. An example from the chat transcripts: ―Guys to be fair to everyone, I suggest that capital players contribute 3 and labour 6 each – in that way we reach our target of 240" and ―for me anything is fine as long as it is 1 to 2 between capital and labour".

Equity

Equity, on the other hand, is a concept of fairness that relies in a proportional way on individual capacity (Reuben and Riedl 2009). Thus, in this design, equity would be linked to the fact that players with a low MCA are twice as productive as high-MCA player-types in reducing emissions, and they should therefore reduce twice the amount of emissions. Contribution strategies reflecting the principle of equity (again in terms of emissions reduced or contributions to the public good) advocated that high and low-MCA players contribute the same number of ECUs towards mitigation. For example, if both player-types contribute 4 ECUs to the mitigation account, in terms of the framing, low-MCA players are reducing emissions by 80 units while high-MCA players are reducing emissions by 40 units.

In a few instances, participants advocated that low-MCA players (capital) contribute more tokens relative to high-MCA players (labour). We also classify such a contribution strategy under equity. An example from the chat transcripts reflecting the principle of equity is as follows: ―It is best if we capital contribute 6 and labour contribute 4…"

Table 4 summarises the final group consensus reached from the online pre-play communication sessions. 26% of groups were unable to reach a consensus on a contribution strategy, 65% of groups were able to reach consensus and agreed on a contribution strategy of equality of income where all group members agreed to contribute their full endowment to mitigation and, finally, 15% of groups reached consensus on a contribution strategy reflecting the principles of equity and equality – both in terms of emissions reduced and contributions to the public account.

Table 4. Group contribution strategy, treatments (2 and 3 pooled)

	No consensus	Equality of income	Other
Number of groups (*n=34*)	9 (0.26)	20 (0.65)	5 (0.15)

Note: Percentages in parenthesis

The result that heterogeneity impedes consensus in climate talks is reflected in multilateral climate change negotiations. While the UNFCCC calls for the ―widest possible cooperation by all countries" (UNFCCC 1992: 2), multilateralism has failed to yield consensus on an equitable and legally binding treaty after the first commitment period of the Kyoto Protocol is concluded. Of particular contention are the long-held UNFCCC principles of historical responsibility and differential responsibilities. Developed countries insist that large emerging economies accept mitigation obligations; the exemption of these economies, coupled with green funding, is considered to give emerging economies a major competitive edge (Saran 2010). Conversely, emerging economies still contend that historical responsibility lies firmly at the feet of the developed world and that reducing emissions is of lower priority than growth and development. Lack of consensus is not found solely along developed-developing country lines. Because the United States refused to accept multilaterally negotiated mitigation obligations, other developed countries became reluctant to agree to a second phase of commitments under the Kyoto Protocol (Saran 2010); Japan, Russia and Canada have subsequently opted out of the second commitment period. In a domestic context, stakeholder participation often fails to produce consensus on how to reach a mitigation target. Sources of contention include the choice of policy instrument, for example, an emissions trading scheme versus a carbon tax and, in the case of a tax, whether the cost of the carbon tax is levied on the consumer or the producer.

Average Contributions

Observation 6: Communication significantly improves average contributions.

Observation 7: Nonbinding verbal communication is cheap talk.

With communication, average contributions of low-MCA players increased to 47.5% of endowment as compared to 41.3% for high-MCA player-types. Relative to the baseline treatment, average contributions increased significantly for both player-types with the introduction of pre-play communication (Table 2). In Wilcoxon signed-rank tests, for the average contribution, $p = 0.001$; for the low-MCA player-type, $p = 0.018$; and for the high-MCA player-type, $p = 0.034$. In addition, average contributions of the two player-types do not differ significantly with communication (Mann-Whitney test: $p=0.184$).

The impact of pre-play communication on contributions to the public good (mitigation) was also tested via an OLS regression using the pooled data from the baseline and communication games in pooled treatments 2 & 3 (Table 5). Regression 2 confirms that pre-play communication significantly improves average contribution levels. Regression 3 confirms that contributions of players with low abatement costs significantly increase with pre-play communication. While Regression 4 confirms that high-MCA player-types significantly increased average contributions after pre-play communication, the F-statistic implies that all coefficients are jointly equal to zero. Regression 5 indicates that the contributions of the different player types do not differ in the communication treatment.

Table 5. Contributions to the public good, by treatment and player-type, treatments 2 & 3 (pooled)

Dep var: Contribution level					
	(1)	(2)	(3)	(4)	(5)
	(Baseline)	*(Baseline & Comm.)*	*(Baseline & Comm.) (Low-MCA players)*	*(Baseline & Comm.) (High-MCA players)*	*(Comm.)*
Treatment	-0.821*	-0.993*	-1.628**	-0.336	-1.156
	(0.495)	(0.524)	(0.675)	(0.790)	(0.719)
Session	0.565	0.496	1.310*	-0.234	0.420
	(0.493)	(0.526)	(0.690)	(0.806)	(0.725)
Communication	-	1.235***	1.324***	1.147**	-
	-	(0.317)	(0.429)	(0.477)	-
Low-MCA player	0.443	-	-	-	0.737
	(0.506)	-	-	-	(0.726)
Gender	0.197	0.003	0.263	0.007	-0.179
	(0.477)	(0.533)	(0.694)	(0.799)	(0.738)
Age	0.008	-0.107	-0.217	-0.013	-0.266
	(0.131)	(0.145)	(0.166)	(0.267)	(0.209)
Constant	2.865	5.713*	8.100**	3.540	10.096**
	(2.762)	(3.120)	(3.604)	(5.701)	(4.508)
Prob > F	0.420	0.003	0.005	0.2954	0.381
R-squared	0.039	0.056	0.144	0.026	0.042

Notes: Standard errors are adjusted for clustering;*, **, and *** indicate significance at the 10%, 5% and 1% level, respectively. Variables included in the regression include dummy variables for the experiment sequence and session, the communication treatment, player-type, and gender, as well as a variable for age.

While average contributions have increased significantly relative to the baseline game, contribution rates are lower when compared to unframed studies involving communication and homogeneous subjects. In a comparable study, Bochet et al. (2006) find that average contributions, after an online chat session, average 81.4% over ten periods (contribution rates start at 93.3% of endowment in period one, declining to 78.3% in period nine and 52.1% in period ten).

It is interesting to note that, in the context of the agreements reached by groups at the end of their online discussion, there was no instance where all four group members complied in terms of the contributions required by their group's adopted contribution strategy (for example, where 65% of groups agreed that all players should contribute their full endowment to mitigation). It is clear that, even though negotiations were often successful, the non-binding nature of the agreements and lack of enforcement mechanisms allow players to deviate significantly from their agreements. The implication for climate change is that, while multilateralism and stakeholder participation are useful mechanisms for facilitating cooperation, sanctioning opportunities are important in order to prevent parties to the negotiations reneging on verbal agreements.

The Distribution of Contributions to Emissions

Table 6 reflects the frequency of contributions to mitigation (public good) for the pooled baseline and communication treatments, by player-type.

Observation 8: Free-riding and perfect cooperation increase with communication.

Observation 9: Contributions are polarized between free-riding and perfect cooperation.

Observation 10: Players with high marginal abatement costs are more likely to free-ride.

As evident from Table 6, the frequency of free-riding (contributing zero tokens) increases with the introduction of communication. The proportion of low-MCA free-riders increases from 20.6% in the baseline phase to 26.4% with pre-play communication, although this increase is not significant (McNemar Chi-square test: $p = 0.248$). The proportion of high-MCA players free-riding increases significantly from 33.8% in the baseline phase to 45.6% with communication (McNemar Chi-square test: $p = 0.033$). Note that around 71% of low-MCA players and 87% of high-MCA players who free-ride in the baseline phase continue to free-ride in the communication phase.

Finally, high-MCA players free-ride with greater frequency relative to low-MCA players in both the baseline and communication phases. Chi-square tests indicate there to be a statistically significant relationship between player-type and free-riding. For the baseline, $p = 0.083$. With communication, $p = 0.020$.

Table 6. Frequency distributions of contributions—treatments 2 and 3 (pooled)

Treatment	Contribution (tokens)										
	0	1	2	3	4	5	6	7	8	9	10
Average (n=136)											
Baseline	0.272	0.088	0.073	0.125	0.147	0.103	0.066	0.022	0.044	0.000	0.059
Comm.	0.360	0.037	0.052	0.037	0.059	0.059	0.037	0.029	0.022	0.029	0.279
Capital (n=68)											
Baseline	***0.206***	0.103	0.059	0.191	0.162	0.074	0.059	0.029	0.059	0.00	***0.059***
Comm.	***0.264***	0.044	0.074	0.074	0.074	0.088	0.029	0.029	0.000	0.015	***0.309***
Labour (n=68)											
Baseline	***0.338***	0.074	0.088	0.059	0.132	0.132	0.074	0.014	0.029	0.00	***0.059***
Comm.	***0.456***	0.029	0.029	0.000	0.044	0.029	0.044	0.029	0.044	0.044	***0.250***

Players who contribute their full endowment to mitigation (public good) are referred to as perfect co-operators. The percentage of low-MCA players contributing 10 tokens to the public good increased significantly from 5.9% in the baseline phase to 30.9% with communication (McNemar Chi-square test: $p = 0.000$). High-MCA players also show a marked increase in cooperation with the introduction of communication, with the proportion of perfect co-operators increasing significantly from 5.9% to 25% (MacNemar Chi-square test: $p = 0.002$).

Testing the relationship between player-type and perfect cooperation does not yield a statistically significant association in either the baseline or communication treatments (Chi-square tests: Baseline: p =1.000; Communication: $p = 0.445$). This means that the propensity to contribute one's full endowment to public good provision is independent of player-type.

As evident from Table 6, contributions are polarized between free-riding and perfect cooperation. In the baseline phase, 26.5% of low-MCA players contribute either 0 or 10 ECUS to the public good. This proportion increases to 57.3% with communication. Likewise, the proportion of high-MCA players contributing either 0 or 10 ECUs increases from 39.7% to 70.6% in the baseline and communication phases, respectively. Across player-types, in the baseline phase, an average of 33.1% of both player-types contributed either 0 or 10 tokens as compared to 64.0% with communication. Figures 1 and 2 illustrate that the communication phase is dominated by the two contribution strategies of free-riding and perfect cooperation.

Figure 1. Frequency of contributions, Sequence 2 and 3 (pooled), low-MCA player-type

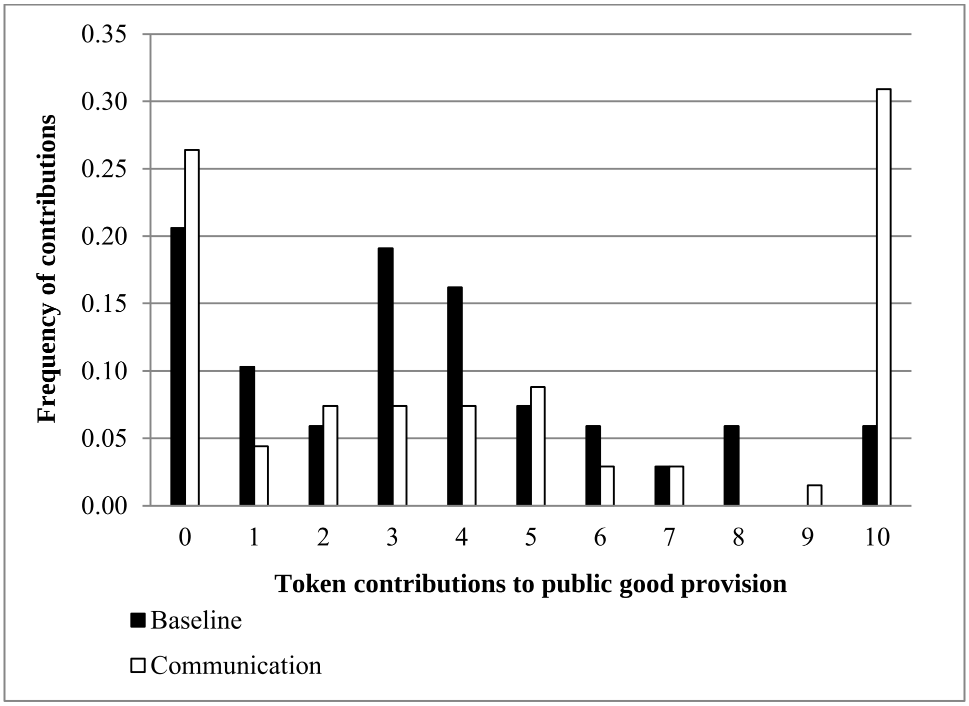
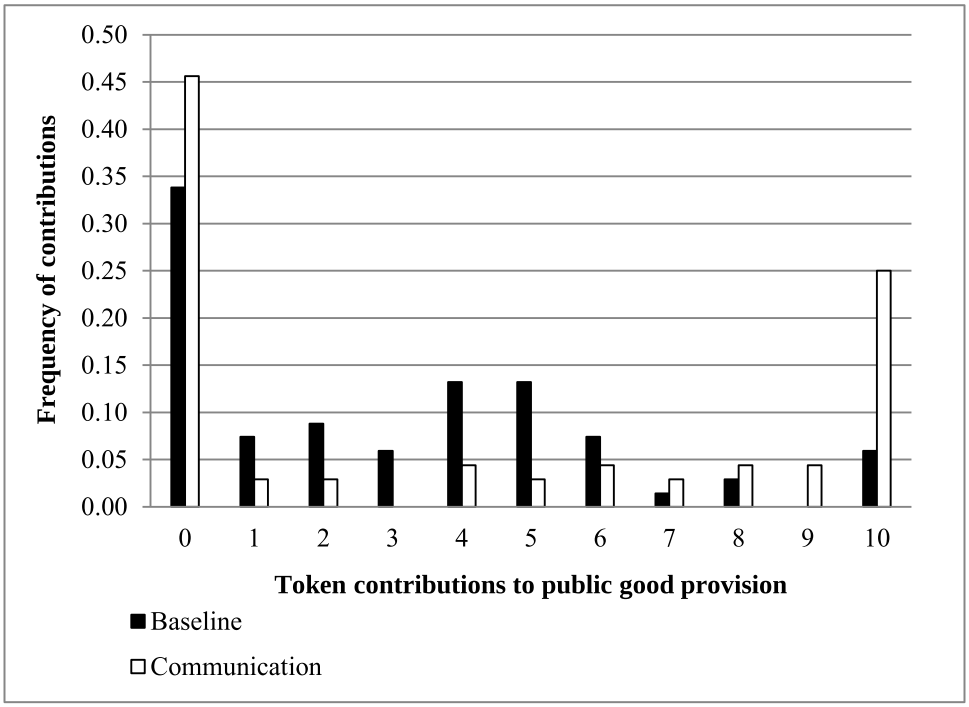


Figure 2. Frequency of contributions, Sequence 2 and 3 (pooled), high-MCA player-type



Meeting the Emission Reduction Target

The introduction of communication facilitated greater success in reaching the emission reduction target. As evident from Table 7, in treatment 1, on average, only 21% of groups met the target in the four baseline phases. In pooled treatments 2 & 3, 35% of groups met the target during the baseline phase. This increased significantly to 50% when participants were allowed to communicate with one another (McNemar test: $p = 0.0075$). This result corresponds with that of Tavoni et al. (2011), where, with the introduction of nonbinding communication, 60% of groups met the threshold.

In addition, while an emission reduction of 240 was urged, average group contributions in all the baseline phases fall short of this target: average group contributions across the four baseline phases in treatment 1 are 143.1, with average group contributions of 196.8 in the pooled baseline phase in treatments 2 & 3. Conversely, average group contributions in the pooled communication phase are 272.6, exceeding the target.

Table 7. Success in Meeting the Emission Reduction Target

Group Emission Reduction Target: 240[1]						
	Sequence 1				Sequence 2 & 3	
	Baseline 1	Baseline 2	Baseline 3	Baseline 4	Baseline	Comm
% of groups that met the target	0.24	0.24	0.12	0.24	0.35	0.50
Average group emission reduction	169.4	128.8	132.4	141.8	196.8	272.6
No. of groups	17	17	17	17	34	34

Discussion and Conclusion

While multilateral climate negotiations act as a mechanism for cooperation, they have failed to induce widespread participation. The experiment reported here considers whether cooperation is possible in such a climate change context. As heterogeneity is a crucial characteristic of climate talks, we use a public good game with a climate change framing to examine whether groups of heterogeneous individuals can meet a collective emission reduction target through individual contributions. Subjects are able to communicate with one another in order to determine how to distribute the abatement burden between two different sectors of society.

The current model for tackling climate change is a top-down approach whereby emission reduction targets are negotiated at international climate talks and then implemented on a domestic level. This implementation phase requires very different groups, for example, businesses, rich and poor households, farmers, lobbyists, environmentalists, and oil and mining companies, to work together to reduce emissions.

Stakeholder participation is increasingly seen as an important component of the formulation of policy responses to climate change, and in natural resource management more generally (Few et al. 2007; Parkins and Mitchell 2005; Kasemir et al. 2003). Without incorporating the public's viewpoints, climate policy is likely to be stalled very early on in the implementation phase (Kasemir et al. 2003). Accordingly, our results show that stakeholder participation plays a valuable role in helping players to coordinate mitigation strategies and subsequently reach the reduction target, even when players are heterogeneous. As previously mentioned, players were urged to meet a national emission reduction target of 240 units. Without the opportunity to communicate with group members, only 35% of groups (in pooled treatments 2 & 3) were able to meet the target. When able to coordinate strategy via online communication, however, this proportion increased significantly to 50%. In addition, average group contributions reached the reduction target only after communication, and in this instance actually exceeded the target.

Isaac and Walker (1988) note that communication facilitates cooperation by helping participants to understand the profit implications of different contribution strategies and builds credibility in terms of the expected decisions of group members. This is reflected in the following excerpts from the chat transcripts: “basically if we want to maximise incomes for everyone, we need to pay 10 tokens each”,“10 is perfect, that way we all get R30”, “but everyone still needs to contribute all tokens to maximize our income” and “okay guys let’s do this, 10 everyone!”

However, the results also indicate that the success of communication is limited in such a climate change context where players are heterogeneous. Firstly, the presence of within-group heterogeneity made it more difficult for groups to reach consensus on a contribution strategy. Specifically, 26% of groups were unable to reach consensus. Secondly, the results illustrate the problem with non-binding, piecemeal agreements. While 65% of groups agreed that each member would contribute his/her full endowment to the public account, there was no group in which this actually happened. In addition, the prevalence of free-riding increased by 5.8% for low-MCA player-types and 11.8% for high-MCA player-types with the introduction of communication. Finally, cooperation was polarized between free-riding and perfect cooperation.

These results indicate that, while stakeholder participation is important in promoting cooperation, there is always the risk that free-riders will engage in participatory processes on the formulation of climate policy, but then thwart efforts at the implementation phase. For example, free-riding individuals might lobby their government when a climate bill is going through congress or free-riding governments might renege on an agreed-to mitigation obligation. The implication is that punishment opportunities will likely play an important role in inducing cooperation. In this context, there is an emerging literature which indicates that the inclusion of punishment opportunities in a heterogeneous public good context improves cooperation (Reuben and Riedl 2009; Tan 2008; Noussair and Tan 2009). An example of an existing sanctioning system is the Renewable Obligation system in the United Kingdom whereby an electricity supplier that fails to sell a specified portion of electricity generated from renewable sources is fined.

The experimental data indicated that players with a high MCA are more likely to free-ride relative to players with a low MCA. This result was more significant in the communication phase. The implication is that the presence of heterogeneity, which is translated within the framework of the game as an inequality, provides individuals with a justification to either refuse to cooperate or to renege on an agreement, assuming one was reached. In a climate change context, parties to the negotiations who view themselves as at an unfair disadvantage, for example, developing countries that are poorer and not historically responsible for emissions, are more at risk of non-compliance. Participatory processes must thus take cognisance of the equity contexts within which the negotiations are happening.

Finally, while communication increased cooperation, the outcome was not sufficient. Let's assume that the specified target of 240 units was part of a multilateral climate treaty, with the aim of keeping temperature warming below 2 degrees, the threshold for catastrophic climate change. In such a context, if only 50% of the population met the target, catastrophic climate change would not be averted. Thus, while participatory processes play an important role in facilitating mitigation, such processes are not sufficient on their own. Brick and Visser (2010) find taxation to be an effective mechanism for inducing compliance with the mitigation target, with the proviso that the tax level is set at the appropriate level. While often unpopular, exogenous regulation, such as a carbon tax, must be coupled with stakeholder engagement to move society to a lower emissions path.

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Appendices

Appendix A. Attitudes towards climate change

	Subjects N=204
Do GHG emissions effect global warming?	
Yes, to a large extent	0.73
Yes, partially	0.25
No	0.02
Are human activities responsible for climate change?	
Yes, to a large extent	0.71
Yes, partially	0.27
No	0.01
Should the government be formulating a climate change policy which includes quantifiable emission reduction targets?	
Yes, definitely	0.59
Yes, probably	0.37
No, probably not	0.02
No, definitely not	0.02
Should firms be obligated to meet emission reduction targets?	
Yes, definitely	0.77
Yes, probably	0.19
No, probably not	0.04
No, definitely not	0.00
Should households be obligated to meet emission reduction targets?	
Yes, definitely	0.15
Yes, probably	0.36
No, probably not	0.38
No, definitely not	0.11

Appendix B.Emission reduction, by player-type, per token invested in mitigation

Tokens	Player-type	
	Low-MCA	High-MCA
0	0	0
1	20	10
2	40	20
3	60	30
4	80	40
5	100	50
6	120	60
7	140	70
8	160	80
9	180	90
10	200	100

Appendix C. Experiment instructions

Baseline treatment

Introduction

You are about to participate in an economics experiment that is part of a long term research project on how best to combat the negative effects of climate change.

The following pages contain the instructions, which we are going to go through now. You will need to make various decisions throughout the experiment so it is important to ensure that you understand the instructions. If at any point something is unclear to you please raise your hand and someone will respond. In addition to making various decisions during the course of the experiment, you will be required to answer some questions.

Please note that the researchers will not attempt to identify you with any of the decisions made or answers provided during the experiment or to name you as a participant in the study; nor will they facilitate anyone else's doing so. We have given each person an experiment number in order to ensure anonymity.

Unless told otherwise, communication with anybody except the experimenters is strictly prohibited.

The game is played in groups of four - thus it will be you and three other players in your group. Nobody except for the experimenters will know who is in which group. You will not learn the identity of the other three members of your group, neither during nor after the experiment. Please note that your **group members will change throughout the experiment: the experiment consists of various different parts and you will be randomly assigned to a new group at the start of each part.**

Players can represent either **Capital** or **Labour**. You can also think of this as players either representing firms (Capital) or households (Labour). We have handed out a piece of paper to all of you which specifies which factor of production you represent. Please take a look now.

Please note that your factor of production allocation will remain the same throughout the experiment.

Note that in each group of four: two players will be representatives for Labour and two players will be representatives for Capital.

Everyone in the group has the same initial wealth and is given the same information to help make their decisions.

1.1 Payment

Just for participating you will be paid R20. Depending on your decisions and the decisions of other players in your group, you may earn considerably more money. The amount you make will be paid to you at the end of this experiment **as a cash cheque, which you can exchange for cash at any ABSA bank.**

During the experiment we will not speak of Rands but rather of tokens. First your whole income will be calculated in tokens. At the end of the experiment, the whole amount you have earned in tokens will be converted to Rand at the following rate and paid out as a cash cheque:

1 token = R0.20

You will need to fill in and sign a receipt in order to receive your payment, but this information is strictly for UCT payment purposes and will not be used in the experiment.

1.2 Context

This experiment deals with how to distribute the burden of reducing harmful greenhouse gas emissions between different sectors of society.

For the purposes of this experiment we assume that the South African government **sets a national target for the reduction of emissions.**

You must decide how to allocate the responsibility of meeting this target between Capital (firms) and Labour (households).

You (representing either labour or capital), and each of your group members, will be given an initial endowment of 10 tokens. You must decide how much of this endowment to invest in the environment. When you invest in the environment, you are investing in the reduction of harmful greenhouse gas emissions to combat climate change.

2 Instructions

2.1 Procedure of the Experiment

Each member of the group receives 10 tokens and has to decide how to invest these 10 tokens.

You can contribute to either a Private Account or a Public Account.

You can either:

- put all these 10 tokens into your Private Account and nothing into the Public Account
- put nothing into the Private Account and all 10 tokens into the Public Account
- put some of the 10 tokens into the Public Account and the remainder in the Private Account.

Therefore, each group member has to decide for himself or herself how much of his or her 10 tokens to put into the Private Account and the Public Account.

By contributing to the Public Account you are choosing to invest in the environment and combat climate change through a reduction of harmful greenhouse gas emissions.

2.2 Income from the Private Account

Capital and Labour representatives earn income from investing in the Private Account.

The Private Account represents investment opportunities other than investing in the environment (i.e. in mitigation). Because Capital (Firms) can more easily invest in productive (income-generating) activities as compared to Labour (households), Capital earns a higher return from money invested in the Private Account relative to Labour.

Capital's income from the Private Account:

For each token that a Capital player chooses to invest in the Private Account, he/she will earn 12 tokens:

Capital Player's private income = (tokens invested in the Private Account) ×12

Labour's income from the Private Account:

For each token that a Labour player chooses to invest in the Private Account, he/she will earn 6 tokens:

Labour Player's private income = (tokens invested in the Private Account) ×6

Example 1:

How much PRIVATE income do Capital and Labour earn if both players invest 0 tokens in the Public Account?

Answer:

Capital Player's private income = (tokens invested in the Private Account) ×12

Capital Player's private income = ***10*** *×12*

Capital Player's private income = 120

Labour Player's private income = (tokens invested in the Private Account) ×6

Labour Player's private income = ***10*** *×6*

Labour Player's private income = 60

(If a player invests 0 tokens in the public account, then they keep all 10 tokens for their private account)

Example 2:

How much PRIVATE income do Capital and Labour earn if both players invest 4 tokens in the Public Account?

Answer:

Capital Player's private income = (tokens invested in the Private Account) ×12

Capital Player's private income = ***6*** *×12*

Capital Player's private income = 72

Labour Player's private income = (tokens invested in the Private Account) ×6

Labour Player's private income = ***6*** *×6*

Labour Player's private income = 36

(If a player invests 4 tokens in the **public account**, then they keep all 6 tokens for their **private account**)

2.3 Contributions to the Public Account (reducing emissions)

As previously mentioned, when you allocate tokens to the Public Account, you are investing in the environment and reducing greenhouse gas emissions. Therefore, the total sum of tokens in the Public Account represents the emissions reductions of your group.

Because firms emit more pollution than households, it is cheaper for them – relative to households - to reduce emissions. This means that Capital is able to reduce more emissions with 1 token than Labour is able to.

Therefore **Capital's contribution to the Public Account is multiplied by 20 while Labour's contribution to the Public Account is multiplied by 10**.

The total amount of pollution reduced by your group is calculated as follows:

Emissions reduced = $(K_1 \times 20) + (K_2 \times 20) + (L_1 \times 10) + (L_2 \times 10)$

Where K_1 = Capital Player 1's contribution to the Public Account

K_2 = Capital Player 2's contribution to the Public Account

L_1 = Labour Player 1's contribution to the Public Account

L_2 = Labour Player 2's contribution to the Public Account

We can see from the formula that Capital is able to contribute more to emissions reductions. This is also clear from the table below which shows **emissions reductions per token.**

Emissions reduction per token contributed by Capital and Labour

Tokens	Capital	Labour
0	0 *(0*20)*	0 *(0*10)*
1	20 *(1*20)*	10 *(1*10)*
2	40 *(2*20)*	20 *(2*10)*
3	60 *(3*20)*	30 *(3*10)*
4	80 *(4*20)*	40 *(4*10)*
5	100 *(5*20)*	50 *(5*10)*
6	120 *(6*20)*	60 *(6*10)*
7	140 *(7*20)*	70 *(7*10)*
8	160 *(8*20)*	80 *(8*10)*
9	180 *(9*20)*	90 *(9*10)*
10	200 *(10*20)*	100 *(10*10)*

- When Capital allocates 5 tokens to the Public Account, there is a reduction of 100 units of emissions
- When Labour allocates 5 tokens to the Public Account, there is a reduction of 50 units of emissions

So if Capital contributes 1 token to the Public Account, the decrease in emissions is greater than if Labour contributes 1 token.

Example 1:

Calculate the reduction in emissions if both Capital players each contribute **10** tokens to the Public Account and both Labour players each contribute **0** tokens to the Public Account.

K_1	K_2	L_1	L_2	
$K_1 \times 20$	$K_2 \times 20$	$L_1 \times 10$	$L_2 \times 10$	
(**<u>10</u>**) × 20	(**<u>10</u>**) × 20	(**<u>0</u>**) × 10	(**<u>0</u>**) × 10	= 400
400		0		

In this case, pollution is reduced by **400** units.

Example 2:

Calculate the reduction in emissions if both Capital players each contribute **0** tokens to the Public Account and both Labour players each contribute **10** tokens to the Public Account

K_1	K_2	L_1	L_2	
$K_1 \times 20$	$K_2 \times 20$	$L_1 \times 10$	$L_2 \times 10$	
(**<u>0</u>**) × 20	(**<u>0</u>**) × 20	(**<u>10</u>**) × 10	(**<u>10</u>**) × 10	= 200
0		200		

In this case, pollution is reduced by **200** units.

Example 3:

Calculate the reduction in emissions if Capital_1 contributes **3** tokens, Capital_2 contributes **2** tokens, Labour_1 contributes **6** tokens and Labour_2 contributes **7** tokens to the Public Account, respectively.

K_1	K_2	L_1	L_2	
$K_1 \times 20$	$K_2 \times 20$	$L_1 \times 10$	$L_2 \times 10$	
(**<u>3</u>**) × 20	(**<u>2</u>**) × 20	(**<u>6</u>**) × 10	(**<u>7</u>**) × 10	= 230
100		130		

In this case, pollution is reduced by **230** units.

2.4 Income from the Public Account (reducing emissions)

Players earn a payoff/income from investing in the Public Account – there is a payoff from reducing emissions. You can think of this payoff as representing a package of benefits from emissions reductions: increased air quality, reduced probability of environmental disasters, greater rainfall in certain parts of the country (greater availability of water resources) and a reduced threat to public health from the increased incidence of malaria.

As previously mentioned, once every group member has decided how much to contribute to the Public Account, the experimenter will **multiply capital's total contribution by 20 and labour's total contribution by 10 (this determines the groups' contribution to emission reduction)**. The total amount in the Public Account will then be divided equally between the **four** group members.

So the income each group member receives from the Public Account is calculated as follows:

$$\frac{(K_1 \times 20) + (K_2 \times 20) + (L_1 \times 10) + (L_2 \times 10)}{4}$$

Where K_1 contribution = Capital Player 1's contribution to the Public Account

K_2 contribution = Capital Player 2's contribution to the Public Account

L_1 contribution = Labour Player 1's contribution to the Public Account

L_2 contribution = Labour Player 2's contribution to the Public Account

Note that because the environment is a public good no one can be excluded from reaping the benefits of emissions reductions so every group member receives the same amount of money out of the Public Account, **no matter what his or her contribution was.**

Example 1:

Calculate your income from the Public Account if both Capital players each contribute **3** tokens to the Public Account and both Labour players each contribute **6** tokens to the Public Account.

Your income from the Public Account: (this income is the same for all group members)

K_1	K_2	L_1	L_2
$K_1 \times 20$	$K_2 \times 20$	$L_1 \times 10$	$L_2 \times 10$
(**3**) × 20	(**3**) × 20	(**6**) × 10	(**6**) ×10

$$\frac{\underbrace{(3)\times 20 + (3)\times 20}_{120} + \underbrace{(6)\times 10 + (6)\times 10}_{120}}{4} = 60 \textit{ tokens}$$

Example 2:

Calculate your income from the Public Account if both Capital players each contribute **6** tokens to the Public Account and both Labour players each contribute **3** tokens to the Public Account.

Your income from the Public Account:

K_1	K_2	L_1	L_2
$K_1 \times 20$	$K_2 \times 20$	$L_1 \times 10$	$L_2 \times 10$
(**6**) × 20	(**6**) × 20	(**3**) × 10	(**3**) ×10

$$\frac{\underbrace{(6)\times 20 + (6)\times 20}_{240} + \underbrace{(3)\times 10 + (3)\times 10}_{60}}{4} = 75 \textit{ tokens}$$

2.5 TOTAL Income

Follow **3 steps** to calculate your **total income**:

Step 1: Calculate your income from the Private Account:

Capital Player's private income = (tokens invested in the Private Account) × 12

Labour Player's private income = (tokens invested in the Private Account) × 6

Step 2: Calculate your income from the Public Account:

$$\frac{(K_1 \times 20) + (K_2 \times 20) + (L_1 \times 10) + (L_2 \times 10)}{4}$$

Step 3: Add your PRIVATE income and your PUBLIC income together

Total income = Private Income + Public Income

Now let's use the payoff tables that have been handed out to you (orange sheet) to look at the following symmetric examples:

Example 1:

Calculate your TOTAL income if all players contribute **0** tokens to the Public Account.

Example 2:

Calculate your TOTAL income if both Capital players each contribute **10** tokens to the Public Account and both Labour players each contribute **10** tokens to the Public Account.

Example 3:

Calculate your TOTAL income if both Capital players each contribute **10** tokens to the Public Account and both Labour players each contribute **0** tokens to the Public Account.

Example 4:

Calculate your TOTAL income if both Capital players each contribute **0** tokens to the Public Account and both Labour players each contribute **10** tokens to the Public Account.

3 Emissions reduction target

The South African government has set a ***national emission reduction target* of 240**. This target is in line with government's multilateral climate change obligations.

The Government is committed to meeting this target and asks Capital and Labour players to ensure that this target is met.

However, at this stage, players won't be penalised for failing to meet the target.

Government envisions that this target will be split between Capital and Labour.

As evident from the table below, the emissions reduction target of 240 can be met through Capital and Labour investing different combinations of tokens in the Public Account.

You can look on your calculator to see some of the many combinations of Capital and Labour contributions that amount to an emissions reduction of 240. We will go through two examples in a moment.

Emissions reduction per token contributed by Capital and Labour

Tokens	Capital	Labour
0	0 *(0*20)*	0 *(0*10)*
1	20 *(1*20)*	10 *(1*10)*
2	40 *(2*20)*	20 *(2*10)*
3	60 *(3*20)*	30 *(3*10)*
4	80 *(4*20)*	40 *(4*10)*
5	100 *(5*20)*	50 *(5*10)*
6	120 *(6*20)*	60 *(6*10)*
7	140 *(7*20)*	70 *(7*10)*
8	160 *(8*20)*	80 *(8*10)*
9	180 *(9*20)*	90 *(9*10)*
10	200 *(10*20)*	100 *(10*10)*

Remember that Capital is able to reduce more emissions with 1 token than Labour is able to!

The following examples indicate the reduction in emissions through Capital and Labour investing different combinations of tokens in the Public Account.

Example 1:

K_1		K_2		L_1		L_2	
K_1×20	+	K_2×20	+	L_1×10	+	L_2×10	= 0
(**0**) × 20		(**0**) × 20		(**0**) × 10		(**0**) × 10	
0				0			

Government's pollution reduction target is not met.

Example 2:

K_1		K_2		L_1		L_2	
K_1×20	+	K_2×20	+	L_1×10	+	L_2×10	= 240
(**4**) × 20		(**4**) × 20		(**4**) × 10		(**4**) × 10	
160				80			

Government's pollution reduction target is met.

Note: the emission reduction target has been met with all players contributing 4 tokens. This means that each Capital player reduced emissions by 80 while each Labour player reduced emissions by 40.

Example 3:

K_1		K_2		L_1		L_2	
K_1×20	+	K_2×20	+	L_1×10	+	L_2×10	= 240
(**3**) × 20		(**3**) × 20		(**6**) × 10		(**6**) × 10	
120				120			

Government's pollution reduction target is met.

Note: the emission reduction target has been met with Capital players contributing 3 tokens and Labour players contributing 6 tokens. This means that all players have reduced emissions by 60.

Example 4:

K_1		K_2		L_1		L_2	
$K_1 \times 20$	+	$K_2 \times 20$	+	$L_1 \times 10$	+	$L_2 \times 10$	
(**<u>10</u>**) × 20		(**<u>10</u>**) × 20		(**<u>10</u>**) × 10		(**<u>10</u>**) × 10	= 600
400				200			

Government's pollution reduction target is exceeded.

Please consider your summary table once again (your pink form).

Experiment 1

Your experiment number: ______

Decision Sheet

You have been allocated 10 tokens. You must decide how to allocate these tokens between the Public and Private Accounts.

Government has publicly announced a national Emission Reduction Target of 240 in line with its multilateral obligations. **The government is committed to meeting this target and asks Capital and Labour to ensure that the target is met.** However, at this stage, players won't be penalised for failing to meet the target.

Please write down how many tokens you want to contribute to **the Public Account (invest in the environment)**:

tokens

(You can only invest a maximum of 10 tokens; use only whole numbers; the rest is automatically put into the Private Account)

Communication treatment

Introduction

Once again, you have been allocated ten tokens which you must allocate between the Private Account and the Public Account.

You have now been assigned to a new group; your factor of production allocation **has not changed.**

The South African government has set a ***national emission reduction target* of 240**. This target is in line with government's multilateral climate change obligations.

The Government is committed to meeting this target and asks Capital and Labour players to ensure that this target is met.

However, at this stage, players won't be penalised for failing to meet the target.

The target of 240 can be reached through Capital and Labour investing different combinations of tokens in the Public Account.

During this experiment, **you may communicate online with the players in your group** in order to discuss how much you each think each player should each contribute to the Public Account.

You now have an opportunity to discuss what would be best for the group and decide how to meet the target.

Towards the end of the online discussion session, once you have discussed what you each feel is an appropriate contribution from each player, each group must vote on the amount of tokens that Capital and Labour should contribute to the Public Account. You will be prompted when it is time to vote.

Note that whatever group consensus is reached, the final decision you make is still your own and your decision will not be made public.

If you have any questions or are unsure about anything please raise your hand. Once everyone is ready you may begin communicating online with the members of your group.

Please consider your summary table once again (your yellow form).

Experiment 2

Your experiment number: ______

Decision Sheet

Once again, you have been allocated 10 tokens. You must decide how to allocate these tokens between the Public and Private Accounts.

Government has publicly announced a national Emission Reduction Target of 240 in line with its multilateral obligations. The government is committed to meeting this target and asks Capital and Labour to ensure that the target is met. However, at this stage, players won't be penalised for failing to meet the target.

Please write down how many tokens you want to contribute to the Public Account (invest in the environment):

tokens

(You can only invest a maximum of 10 tokens; use only whole numbers; the rest is automatically put into the Private Account)

Appendix D. Average contributions

	Sequence 2			Sequence 3		
	Avg. *n=68*	*K* *n=34*	*L* *n=34*	Avg. *n=68*	*K* *n=34*	*L* *n=34*
Baseline	2.78 (2.56)	2.85 (2.36)	2.71 (2.78)	3.63 (3.16)	4 (3.18)	3.26 (3.14)
Comm.	3.82 (3.94)	3.56 (3.59)	4.09 (4.31)	5.06 (4.44)	5.94 (4.24)	4.18 (4.52)

Note: Standard deviations are presented in parentheses

Appendix E. Mann-Whitney tests, baseline treatment, sequence 2 and 3

Sequence 2	Sequence 2
$p = 0.690$	$p = 0.345$

Appendix F. Auxiliary regressions, sequence 2 and 3

	(1)	(2)
Variables	(Baseline & Com.) (Low-MCA players) (Sequence 2)	(Baseline & Com.) (Low-MCA players) (Sequence 3)
Sequence	-	-
	-	-
Session	0.598	1.927*
	(0.904)	(1.038)
Comm.	0.706	1.941***
	(0.532)	(0.677)
Low-MCA player	-	-
	-	-
Gender	0.944	-0.434
	(0.848)	(1.129)
Age	-0.169	-0.268
	(0.346)	(0.188)
Constant	5.816	8.777**
	(6.996)	(4.229)
Prob > F	0.4503	0.0143
R-squared	0.0559	0.1513

Notes: Standard errors are adjusted for clustering;*, **, and *** indicate significance at the 10%, 5% and 1% level, respectively.