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Contribution Norms in Heterogeneous Groups: A Climate Change Framing

by

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Abstract

While results from public good games with homogeneous players reflect the contribution norm of *equal* contributions, it is unclear what contribution norm will arise in a heterogeneous setting. Climate change is a perfect example of a social dilemma involving heterogeneous agents. As such, using a public good game with a climate change framing, this study examines what contribution norm arises when players are asymmetric in terms of their impact on the public good (mitigation). The climate change framing exacerbates equity considerations and ultimately increases the difficulty of finding a generalizable concept of fairness (contribution norm) acceptable to both player-types. The efficacy of communication as a means to promoting public good provision is also considered. The default contribution norm, irrespective of player-type, was to free-ride. With the introduction of communication, two dominant contribution norms emerge: free-riding and perfect cooperation.

Keywords: public good; contribution norm; communication; heterogeneity; climate change
JEL codes: H41, Q54, Q58

1. Introduction

Experimental evidence suggests that behaviour is guided by notions of fairness: results from the lab are consistent with *conditional cooperation* where individuals cooperate when others do so, but defect when others defect (Fischbacher et al., 2001, Fehr and Fischbacher, 2004), and *reciprocity*, where individuals reward kind actions toward them and punish unkind actions (Brekke and Johansson-Stenman, 2008). Bolton and Ockenfels (2000) note that in dictator games, the proposer gives more than the minimal amount expected by theory because of equity concerns; while, in ultimatum games, it is the responders' concerns with equity which cause the proposer to offer more than the minimal amount. Of relevance to this study is that results from public good games with homogeneous players typically reflect the contribution norm of equal contributions (Fehr and Fischbacher, 2004; Gächter and Herrmann, 2009; Reuben and Riedl, 2009). For example, Fehr and Gächter (2000), Fehr and Gächter (2002) and Anderson and Putterman (2006) find that punishment increases as the differential between individual contributions and average group contributions widens; Gächter et al. (2008) conclude that deviations from the punisher's contribution are sanctioned; Masclet et al. (2008) show that punishment is increasing in deviations from both the average group contribution and the punisher's contribution

However, it is unclear as to what contribution norm will arise in a public good setting with heterogeneous players. The ultimate example of a public good dilemma with heterogeneous players is that of climate change mitigation: while society benefits equally by avoiding catastrophic climate change, the private cost associated with mitigation acts as an incentive to free-ride – resulting in an undersupply of the public good (mitigation) (Brekke and Johansson-Stenman, 2008). Successfully reducing greenhouse gas emissions requires cooperation from multiple players with heterogeneous characteristics. On a global scale, international environmental agreements like the Kyoto Protocol require countries with divergent levels of wealth and historical responsibility to agree on how best to distribute an abatement burden; on a national scale, firms and individuals with varied levels of income, energy usage, abatement costs and mitigation capacities must do the same. In such a context, this study considers what contribution norm arises in a public good game with a climate change framing where heterogeneous players. In terms of the climate framing, players can either continue with business-as-usual (contribute to the private account) or reduce emissions (contribute to the public good).

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 with some authors finding endowment asymmetry increases cooperation (Chan et al., 1996, 1999; Buckley and Croson, 2006), and others concluding that cooperation is diminished (Anderson et al., 2008; Cherry et al., 2005). Heterogeneity has also been introduced into a public-good framework 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 capital return (MPCR) within groups. They find that high-MPCR players contribute more to public good provision relative to low-MPCR players.

In this study, asymmetry is introduced in two ways: by varying (i) players' returns from the private account and (ii) their marginal contribution *to* the public good (contributions from one player-type have a greater impact on the public good (emissions reduction) than contributions from another player-type).

In addition to considering what contribution norm arises in a heterogeneous context, we consider the efficacy of communication in promoting cooperation when players are asymmetric.

While standard theory predicts that using communication as a mechanism to foster non-binding agreements between participants (allowing cheap-talk) would not deter participants from deviating from their free-riding strategy (Farrel and Rabin, 1996; Ostrom, 1998), the experimental evidence suggests that communication within a homogeneous public-good setting significantly improves cooperation (Sally, 1995; Ostrom, 1998; Gächter and Herrmann, 2009). Even one-shot public goods games with anonymous players report efficiency improvements after costless non-binding communication has been introduced (Ledyard, 1995). More recent evidence of the positive effect of this type of communication on cooperation can be found in Berlemann (2003), Berlemann et al. (2009) and Bicchieri and Lev-On (2007). Several explanations for the role played by communication have been proposed: Orbell et al. (1990) posit that communication fosters group identity; Farrel and Rabin (1996) argue that communication is a mechanism that helps subjects avoid misunderstandings and coordination failures; Charness and Duwenberg (2006; 2010) build a model based on guilt aversion according to the hypothesis that after communication participants feel the need to live up to the expectations of others; and, finally, Bicchieri (2002) argues that communication elicits social norms.

Papers examining the emergence of contribution norms in homogeneous-group environments tend to focus on punishment (sanctioning) as opposed to communication. The results of such studies imply that punishment is an important tool for facilitating cooperation in asymmetric settings. As in our study, Tan (2008) introduces heterogeneity by varying players' impacts on the public good. The author finds that, in the absence of sanctioning, the presence of asymmetry hinders cooperation. When sanctioning is possible, high productivity players are punished the most and also respond more actively to that punishment. Reuben and Riedl (2009) study the emergence and enforcement of contribution norms for homogenous and a range of heterogeneous groups. They find that without punishment, all groups converge towards the norm of free-riding. However, when punishment is introduced, contributions increase and differ significantly across the different groups and individuals. Further, they find that enforcement of such different contribution norms appears to uphold ideas of fairness, particularly equity in contributions, suggested by the heterogeneous positions of the players.

If communication is an important mechanism through which fairness norms are elicited, it could be a useful tool in promoting cooperation in the context of social dilemmas (such as climate change). However, as previously mentioned, while the literature has considered communication as a means of eliciting fairness norms, it has largely done so in a homogeneous-player context. This experiment considers the effect of communication in facilitating public good provision within a heterogeneous-setting.

Finally, we consider whether communication results in an equitable outcome for all player-types and consider what contribution norm, if any, arises in such a heterogeneous context. While in homogeneous group environments, an equal-contributions norm is intuitively appealing, it is unclear what contribution norm would prevail with asymmetric player-types (Reuben and Riedl, 2009). With respect to the experimental framing, the climate change framing exacerbates equity considerations and ultimately increases the difficulty of finding a generalizable concept of fairness (contribution norm) acceptable to both player-types.

The paper proceeds as follows: the experimental design is presented in Section 2 while the results are discussed is Section 3. The paper concludes with a discussion in Section 4.

2. Experiment

For a more detailed description of the experiment design and procedures, the reader is referred to Brick and Visser (2010); a summary description follows:

2.1. Design and framing

We utilize a linear public goods game with a climate change framing. Players are asked to meet a national emission reduction target where they can invest in mitigation (public account) or continue with business-as-usual (private account).

Players earn 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, returns to mitigation quantify the benefits of reduced likelihood of an extreme weather event. On a national scale, the returns would quantify reduced pressure on the grid as electricity consumption is decreased. Since no one can be excluded from the benefits associated with mitigation, all players earn the same income from the public account.

Investing in the private account, on the other hand, represents investments in other private income-generating activities.

We introduce asymmetry into the payoff structure by varying players' marginal contributions *to* the public good. In terms of the climate change framing: this means that players have different marginal costs of abatement. The experimental design thus assesses how players with differing marginal costs of abatement distribute the responsibility of reducing a national greenhouse gas inventory. While the framing explicitly refers to Capital and Labour, it is important to note that this scenario is applicable to any context in which marginal abatement costs differ. The framing would be equally applicable in the context of two firms or households with differing marginal costs of abatement.

Given that there are the same number of Capital (k) and Labour (l) players in a group of size n and each player has an endowment of Y tokens (experimental currency units) to allocate between a public and private account, the general payoff structure assumes the following form:

$$\pi_{k_i} = \alpha_k \times (Y - C_{k_i}) + \frac{1}{n}\sum_i (\beta_k \times C_{k_i}) + (\beta_l \times C_{l_i}) \quad (1)$$

$$\pi_{l_i} = \alpha_l \times (Y - C_{l_i}) + \frac{1}{n}\sum_i (\beta_k \times C_{k_i}) + (\beta_l \times C_{l_i}) \quad (2)$$

(Where C_{k_i} and C_{l_i} represent the ith Capital and Labour player's contribution to the public account and β_k, β_l and α_k, α_l represent the different investment productivities that the Capital and Labour players have for the private and public accounts respectively.)

The following assumptions are made:

Equal Marginal Per Capita Return (MPCR) assumption

The MPCR[1] for both Capital and Labour players is the same: since the environment is a public good a unit of pollution reduced by a Capital player should have exactly the same benefits as a unit reduced by a Labour player. Thus α_k / β_k = α_l / β_l ,

Abatement Productivity Assumption

Since firms are responsible for a larger proportion of emissions it is relatively cheaper for them to reduce emissions; as such, each token invested by Capital in the public account has a greater impact on public good provision (in this case mitigation) as compared to a token invested by Labour (Capital can reduce more emissions with one token relative to Labour) ($\beta_k > \beta_l$). The implication is that Capital has a lower marginal cost of abatement relative to Labour. **The public good game thus consists of two player-types: a low marginal cost of abatement player-type (low-MCA) (Capital) and a high marginal cost of abatement player-type (High-MCA) (Labour)**.

Private Investment Productivity Assumption

The previous two assumptions taken together imply that $\alpha_k > \alpha_l$ so that α_k / α_l = β_k / β_l . This means that firms also need to earn a proportionally higher return from money invested in the private account. This is plausible because firms are typically more easily able to invest in productive (income-generating) activities than households.

It is important to note that despite having introduced this heterogeneity, the Nash-equilibrium for all players remains contributing nothing to the private account, while the social optimum is reached when all players in the group contribute their entire endowment to the public account (where the public account is synonymous with mitigation).

2.2. Pay-off structure for baseline and communication treatments

Players participate in a baseline and communication treatment. The communication treatment is identical to the baseline treatment except that, before contributing to the

[1] Here defined as the ratio of the return from a token invested in the public account to the return of a token invested in the private account.

public account, group members are allowed to participate in costless online communication. At the end of the discussion, players take a non-binding vote regarding each player-type's contribution. Note that the payoff structure remains the same for both treatments.

The treatments were played in groups of *n*=4, always composed of two Capital players (low-MCA player-types) and two Labour players (high-MCA player-types). Upon commencement of each treatment, each participant is endowment with *y*=10 tokens from which each Capital and Labour player contributes C_{k_i} and C_{l_i} to the public account, respectively (0 ≤ C_{l_i} ≤ 10 and 0 ≤ C_{k_i} ≤ 10). This contribution decision is made privately by all players.

As emphasised, players are asymmetric in terms of their marginal costs of abatement (marginal contributions *to* the public account), with α_k = 12, β_k = 20 and α_l = 6, β_l = 10 (giving both players a MPCR of 0.42).

The implication is that capital (low-MCA player-type) is: (i) twice as productive as labour in reducing emissions and (ii) twice as productive with regards to private investment. Equations 1 and 2 can be rewritten for Capital and Labour as follows:

$$\pi_{k_i} = 12 \times (10 - C_{k_i}) + 0.25\sum_{i=1}^{2}(20 \times C_{k_i}) + (10 \times C_{l_i}) \quad (3)$$

$$\pi_{l_i} = 6 \times (10 - C_{l_i}) + 0.25\sum_{i=1}^{2}(20 \times C_{k_i}) + (10 \times C_{l_i}) \quad (4)$$

where C_{k_i} is the contribution of the ith Capital agent and C_{l_i} is the contribution of the ith Labour agent.

Note that the sum of tokens contributed to the public account by Capital and Labour denotes the emission reduction of the group. Table 1 reflects emission reductions, by player-type, per token investment in the public good.

Table 1: Emission reduction, by player-type, per token invested in mitigation

Tokens	Units emissions reduced	
	Capital	Labour
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

Participants were told that government has set a national emission reduction target of 140 units. This target can be met through Capital and Labour contributing different combinations of tokens to the public account. For example, each Capital and Labour player can contribute 4 tokens to the public account; conversely, each Capital player can contribute 3 tokens while each Labour player contributes 6 tokens. Note that although players were urged to meet the target, the target was not binding in the communication treatment.

2.3. Sample and treatments

The experiment was manually performed and consisted of a sample of 204 students from the University of Cape Town. 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.

The experiment consists of four exogenous treatments: a Baseline treatment, Communication treatment and two tax treatments specifying differing contributions to the public good. Participants were assigned to new groups at the start of each treatment. After these treatments, players were asked to endogenously select a game by voting on the treatment they would like to play again for the final game.

To take order effects into account the experiment was played in three different sequences (Table 2). Payoff information was provided at varying stages of the experiment and, as evident from Table 2, payoff feed-back differs according to sequence: in Sequence 1, payoff feedback is provided at the end of the experiment; in Sequences 2 and 3, in half the sessions, payoff information is provided before voting, while in the remaining sessions, payoff feed-back is provided only at the end of the experiment.

The baseline and communication treatments are discussed in this paper. For a brief review of the baseline and communication treatments and a detailed discussion of the tax treatments, the reader is referred to Brick and Visser (2010).

Table 2: Experiment summary

Treatment	Sequence 1 (Sessions 3&4)	Sequence 2 (Sessions 1&2)	Sequence 3 (Sessions 5&6)
1	Baseline	Baseline	Baseline
2	Baseline	Communication	Tax (2)
3	Baseline	Tax (1)	Tax (1)
4	Baseline	Tax (2)	Communication
Feed-back	Session 3 (No)	Session 1 (No)	Session 5 (No)
	Session 4 (No)	Session 2 (Yes)	Session 6 (Yes)
5	Baseline	Vote and Play	Vote and Play
Feed-back	Yes	Yes	Yes

2.4. Procedures

Each experimental session lasted approximately 2-3 hours (including paying participants). The experiment was conducted in a computerised laboratory in order to take advantage of chat software during the communication stage. Using this chat software, subjects were able to communicate anonymously within their groups. Communication was only allowed during the online chat session at the beginning of communication treatment.

During the experiment the climate change context was emphasized and participants were told that the aim of the research project was to explore 'how to distribute the burden of reducing greenhouse gas emissions between different sectors of society'.

Participants were given a R20 show-up fee; in addition, a rand/token exchange rate was specified at the start of the experiment.[2]

The rules of the game and the parameters of the pay-off functions used in all the treatments were explained to participants before the commencement of each treatment. An excel-based calculator tailored for each player-type was provided to participants for ease of calculation.

2.5. Contribution norms

In experimental treatments involving both communication and homogenous groups; and where equal contributions lead to equal income, it is often implicitly assumed that the emergent contribution norm will be one of equal contributions.(Fehr and Fischbacher, 2004; Reuben and Riedl, 2009). However, when considering heterogeneous groups the allocation rules that will be supported by players during and after communication are less certain.

The literature on contribution norms and fairness provides some guidance on what allocation rules players might advocate (Reuben and Riedl 2009). The two most prominent notions of fairness are that of <u>equality and equity</u> (Konow 2003; Konow et al. 2009). In the public-good-game literature, equality is a concept of fairness that considers all participants as equals, regardless of individual capacity; thus in our game equality would make no distinction between low-MCA player-types (Capital) and high-MCA player-types (Labour) – even though the player-types differ in terms of their marginal abatement costs. 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 Capital is twice as productive as Labour both in reducing emissions and generating income from private investment.

The complexity of these concepts of equality and equity becomes apparent when one realizes that participants can apply them to distinctly different aspects of the same game. For instance, players may apply these concepts to their individual incomes or alternatively they may apply them to what their relative emission reduction contributions should be. In addition, since players were requested to meet an emissions reductions target of 240 units, this target was likely to influence the emergent contribution norms. Table 3 summarises the contribution norms implied by the principles of equality and equity as applied to: (i) emission reductions, (ii) income generated and, (iii), emission reduction target.

Since Capital and Labour players are asymmetric in terms of their marginal contribution to the public good/marginal abatement costs, it is possible that the participants might consider relative contributions to total emission reductions as a way in which to adjudicate the fairness of the outcome (Panel A). Assuming equality is interpreted as equality of emissions

[2] 1 token = R0.25

reduced by the player-types, Labour players need to contribute twice as many tokens to the public account as their Capital counterparts in order for both player-types to reduce emissions by the same amount (column 2).[3] To meet the 240 unit emissions target under such a norm, Capital and Labour players need to contribute 3 and 6 tokens, respectively. If, however, players advocate equity (productivity) in emission reductions, then, since Capital players are twice as productive at reducing emissions as Labour, they would be responsible for reducing twice the amount of emissions. Under such a norm both types of players would need to contribute 4 tokens in order to meet the target of 240 (column 3).[4]

Players may also define fairness in terms of their incomes (Panel B). Due to the heterogeneity in the payoff functions of the Capital and Labour players, the only scenario in which income will be equally distributed amongst players is when all players contribute their entire endowment to the public good, and maximum emission reductions are reached (column 2). In this case, the emissions target of 240 will obviously be exceeded and the social optimum is reached. On the other hand, if the participants advocate equity in income, then those with higher productivity should earn more than those who are less productive. In this design, as Capital is twice as productive as Labour both when contributing to emission reductions and investing in a private account, Capital players should be able to earn twice the income that Labour players do. Such a proposal is not one we would expect to see advocated because in strict application, where Capital earns exactly twice what Labour does, the only way to maintain proportionality of income would be for neither player-type to contribute to emission reductions (column 4).

Table 3: Focal Contribution Norms

Panel A*: Fairness Concepts Applied to Emission Reductions*		
	Equality	Equity to productivity
Implied Contribution Norm	$C_k = 2C_l$	$C_k = C_l$
Norm applied to target	$C_k = 3$; $C_l = 6$*	$C_k = 4$; $C_l = 4$*
Panel B*: Fairness Concepts Applied to Income*		
	Equality	Equity to productivity
Implied Contribution Norm	$C_k = C_l = 10$	$C_k = C_l = 0$
Norm applied to target	$C_k = 10$; $C_l = 10$**	$C_k = 0$; $C_l = 0$***

*Note: *, ** and *** implies target met, target is exceeded and target is not met, respectively.*

These contribution norms consider the notions of equality and equity within a heterogeneous-setting and a climate change framing – and focus exclusively on capacity. However, within a *climate change context*, equity and fairness are also considered in terms of historical responsibility (as well as a number of other burden-sharing rules and principles) (Rive et al., 2006; Torvanger and Ringuis, 2002; Sijm et al., 2001). Within such a context, players may advocate a burden-sharing principle premised on the polluter-pays rule. Such a burden-sharing rule, based on historical responsibility of emissions, would imply that a player whose emissions are x% of total emissions, bears x% of the abatement costs (Lange

[3] Note that equality in emission reductions implies equity in terms of contributions to the public account.
[4] Note that equity in emissions reductions implies equality in terms of contributions to the public account.

et al., 2007). A contribution norm reflecting the polluter-pays rule would thus imply that Capital contribute more tokens to the public good relative to labour.

As the above discussion demonstrates, adjudicating fairness in the climate change scenario is certainly complex and will be made even more so by the fact that individuals frequently support fairness concepts that are self-advantageous (Babcock & Loewenstein, 1997).

3. Results

Including the participation fee, low-MCA player-types (Capital) earned, on average, R152, while high-MCA player-types (Labour) earned an average of R111.

3.1. Baseline contribution levels and norms

Table 4 reflects the average contributions of players across the various treatments.

As evident from Table 4, average contributions (across player-types) in Baseline 1 (sequence 1), Baseline (sequence 2) and, Baseline (sequence 3), range between 2.8 and 3.6 tokens. Contribution levels are in accordance with evidence from the lab suggesting that contribution rates in repeated one-shot public goods games with 'strangers' (here randomly changing group members) undershoot those typically seen in public goods games played repeatedly with the same group members (Gächter and Herrmann, 2009; Keser and van Winden, 2000; Fehr and Gächter, 2000). Fehr and Fischbacher (2003) note that in repeated one-shot public good games, where participants' are cognisant of the lack of need for strategic cooperation, contribution levels are low from the outset. A Kruskal-Wallis test indicates there to be no significant difference among these baseline treatments (p = 0.257).

Table 4: Summary Statistics by Sequence for the relevant treatments

	Sequence 1				Sequence 2				Sequence 3		
	Avg. *n=68*	*K* *n=34*	*L* *n=34*		Avg. *n=68*	*K* *n=34*	*L* *n=34*		Avg. *n=68*	*K* *n=34*	*L* *n=34*
Baseline 1	2.90	2.68	3.12	Baseline	2.78	2.85	2.71	Baseline	3.63	4	3.26
	(2.93)	(2.73)	(3.14)		(2.56)	(2.36)	(2.78)		(3.16)	(3.18)	(3.14)
Baseline 2	2.32	1.79	2.85	Comm.	3.82	3.56	4.09	Comm.	5.06	5.94	4.18
	(2.85)	(2.59)	(3.03)		(3.94)	(3.59)	(4.31)		(4.44)	(4.24)	(4.52)
Baseline 3	2.18	2.26	2.09								
	(2.78)	(2.55)	(3.03)								
Baseline 4	2.35	2.38	2.32								
	(2.76)	(2.90)	(2.66)								

Note: Standard deviations are presented in parenthesis

Average contributions (across player-types) range between 2.2 – 2.9 in the four baseline treatments in sequence 1. Wilcoxon signed-rank tests find only Baseline 1 and Baseline 3 to be statistically different from each other (Baseline 1 versus Baseline 3: p = 0.001; Baseline x versus Baseline y: p > 0.128). A non-significant (but negative) spearman rank order correlation between mean contributions and treatments ($= -0.073$, $p = 0.232$) is expected given the low contribution rates from the outset.

<u>Observation 1: Contributions do not significantly differ by player-type</u>

<u>Observation 2: Free-riding is the dominant contribution norm for both player-types</u>

We consider the average contributions of both player-types in each of the four baseline treatments in sequence 1 as well as the baseline treatments in sequence 2 and sequence 3. Mann-Whitney tests indicate there to be no significant difference between capital and labour contributions in each of these treatments ($p > 0.080$ for all treatments).

In addition to this, free-riding (contributing zero tokens) appears to be the dominant strategy employed by players in the baseline treatments, regardless of player-type. This is demonstrated in Figures 1 – 3 which reflect the frequency of contributions to emissions reductions by sequence and player type for the baseline treatments in Sequence 1, 2 and 3.

Figure 1: Contributions, Baseline treatments, Sequence 1

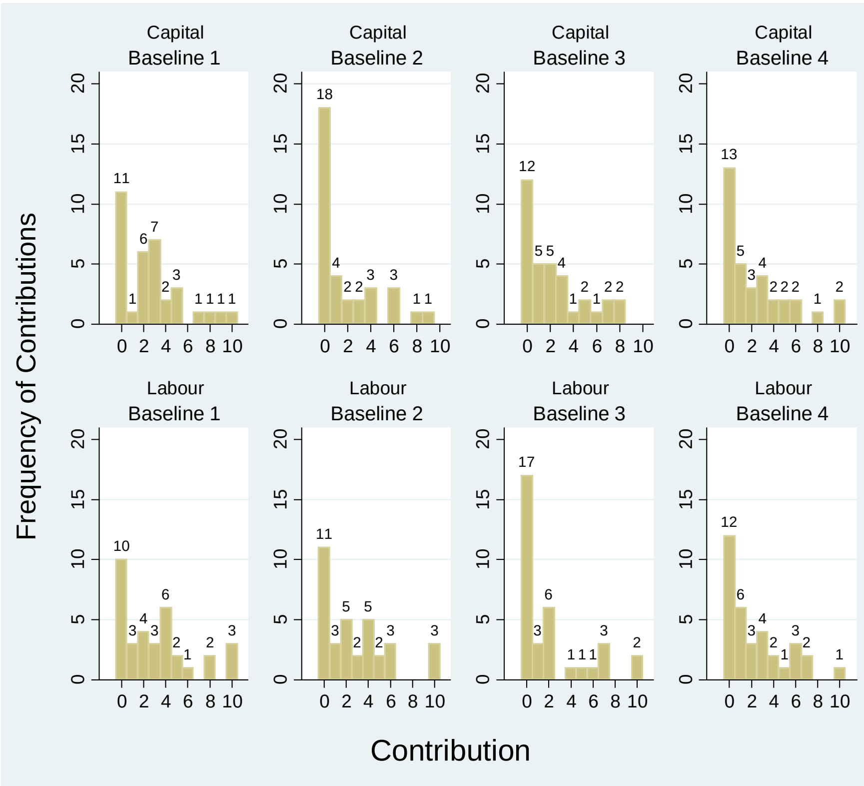


Figure 2: Contributions, Baseline treatment, Sequence 2

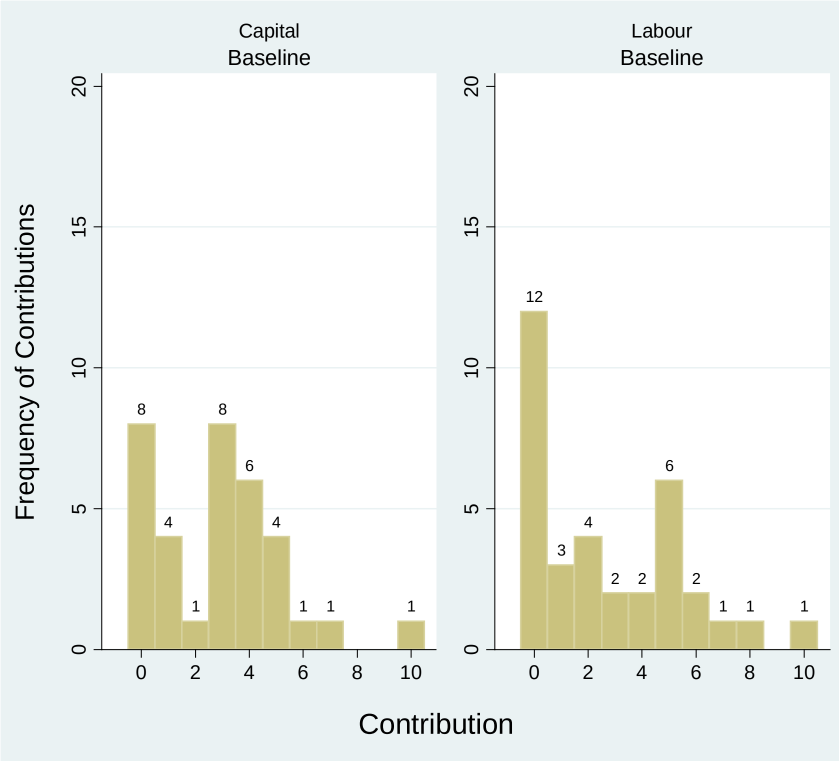
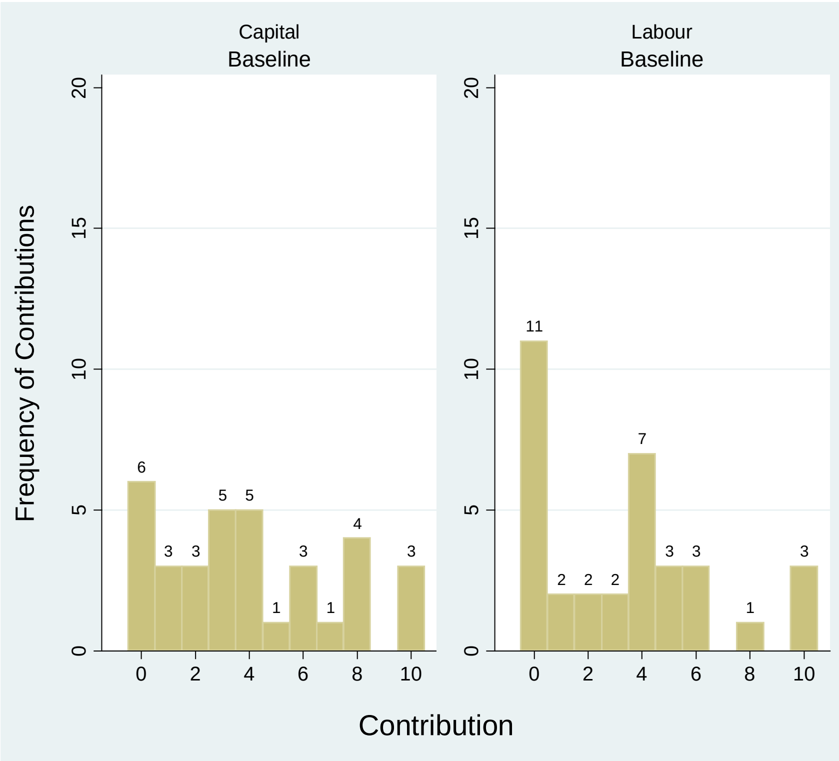


Figure 3: Contributions, Baseline treatment, Sequence 3



3.2. Contribution norms (Sequence 2 and 3)

Observation 3: A contribution norm of equality of earnings is supported by the majority of participants, irrespective of player-type.

While at first many players advocated self-advantageous ideas of equity based on differences in productivity and differing impacts on emissions reductions, more often than not the final agreement was based on simple views of fairness such as equality of income. Table 5 below summarises the resulting agreements from the online communication sessions for both sequences.

Table 5: Contribution norms advocated

Sequence	Agreement Reached (number of Groups)			Total
	Norm of Equality of Income	Other norm supported	No clear consensus	
2	9	3	5	17
3	11	4	2	17
Total	20	7	7	34

During the online discussion period, 27 groups (79%) came to an agreement with relative ease, and solidified this agreement in a vote. The remaining 7 groups, unable to reach an agreement, were unable to ratify their decision with a vote. Of specific interest are the types of agreements that the successful groups were able to come to and what contribution norms these agreements supported. Notably, equality of income (Table 3, Panel B) was the most popular fairness outcome supported by most groups (20 groups – 74% of the successful groups and 58% of all groups).

No one specific allocation was supported by the remaining 7 successful groups. The fairness ideas behind the norms supported by these groups were harder to categorize, but most often seemed to be aimed at achieving equal contributions to the public account.

As the discussion of focal contributions makes clear, equal income is only achievable in this experiment if players contribute their entire 10 tokens to the public account. The enthusiasm with which the majority of players embraced such a high allocation norm in the chat-room needs, however, to be met with some caution. While it is the case that total contribution to the public account by all players is the social optimum and the single point at which equality of income can be achieved, it is also likely that a similar strategy would be promoted by purely self-interested players trying to maximize income by getting others to contribute their total endowment but with the personal intention of contributing less or free-riding. This mixture of motives may explain the relative ease with which players were able to agree on the equality of income as a shared norm despite their different productivity heterogeneities.

3.3. Communication (Sequence 2 and 3)

3.3.1. Average contributions

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 Sequence 2 and 3. Like-treatments in Sequence 2 and 3 have thus been pooled – as reflected in Table 6.

Table 6: Average contributions

	Sequence 1				Sequence 2 and 3		
	Avg. *n=68*	K *n=34*	L *n=34*		Avg. *n=136*	K *n=68*	L *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)				

<u>Observation 4: Communication improves public good provision in heterogeneous-group environments</u>

As evident in Table 6, average contributions (across player-types) (in pooled sequences 2 and 3) increased significantly from 3.21 in the baseline treatment to 4.44 with the introduction of communication (Wilcoxon signed-rank test: p = 0.001). Regression 2 in Table 7 further confirms that communication significantly improves average contribution levels.

Low-MCA player-types (Capital) significantly increased average contributions from 3.34 in the baseline treatment to 4.75 in the communication treatment (Wilcoxon signed-rank test: p = 0.018), an increase, as a percentage of endowment, of 13.2%. Regression 3 (Table 7) again confirms this result. Note that the sequence dummy variable is significant in Regression 3 – implying some ordering effects for Capital. Auxiliary regressions were thus run for Sequence 2 and Sequence 3 separately (Appendix A). While Regression 1 suggests that Capital contributions do not increase significantly with communication in Sequence 2, communication does facilitate increased public good provision in Sequence 3.

High-MCA player-types (Labour) also significantly increased average contributions to 4.13 (or by 11.4% when considered as a percentage of the total endowment) with the introduction of communication (Wilcoxon signed-rank test: p = 0.034). While Regression 4 confirms this result, the F-statistic implies all coefficients are jointly equal to zero.

Finally, a Mann-Whitney test finds no significant difference between the average contributions of Capital and Labour players in the communication treatment (p=0.184). Once again, this is confirmed by regression 5 in Table 7.

Table 7: Contributions to the public good, by treatment and player-type, Sequence 2 and 3

	(1)	(2)	(3)	(4)	(5)
Variables	(*Baseline)*	*(Baseline & Comm.)*	*(Baseline & Comm.) (K players)*	*(Baseline & Comm.) (L players)*	*(Comm.)*
Sequence	-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)
Comm.	-	1.235***	1.324***	1.147**	-
	-	(0.317)	(0.429)	(0.477)	-
Capital	0.443	-	-	-	0.737
	(0.506)	-	-	-	(0.726)
Female	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 the experiment sequence and session, the communication treatment, player-type, gender as well as a variable for age.*

While the results suggest that communication has somewhat improved public good provision, they are more equivocal and less successful when compared to previous evidence involving communication treatments (Sally, 1995). Indeed, average contributions to emission reductions of 44% of endowment (with sizeable standard deviations) seems rather discouraging given that in the previous section we found that 59% of groups came to agreements that required that they contribute 100% of their endowment towards ameliorating climate change.

3.3.2. The distribution of contributions to emissions

The introduction of communication facilitated greater success in reaching the emission reduction target. As evident from Table 8, in Sequence 1, on average, only 21% of groups met the target in the four baseline treatments. In Sequence 2 and 3 (pooled), 35% of groups met the target during the baseline treatments. This increased to 50% when participants were allowed to communicate with one another. In addition, while each groups' emission reduction target was 240, average group contributions in all the baseline treatments fall short of this threshold: average group contributions across the four baseline treatments in Sequence 1 averaged 143.1, while average group contributions in the pooled baseline treatment in Sequence 2 and 3 is 196.8. Conversely, average group contributions in the pooled communication treatment at 272.6 exceed this threshold.

Table 8: Success in meeting the Emission Reduction Target

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

Note: [1] $(K_1 \times 20) + (K_2 \times 20) + (L_1 \times 10) + (L_2 \times 10)$

Despite this improvement in reaching the target, it is interesting to note that, in the context of the agreement 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 groups adopted norm. 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.

Table 9 reflects the frequency of contributions to the public good for the pooled baseline and communication treatments, by player-type.

<u>Observation 5: Communication coupled with a non-binding vote does not induce free-riders to cooperate</u>

<u>Observation 6: The prevalence of free-riding among high-MCA player-types increases significantly with the introduction of communication</u>

As evident from Table 9, 20.6% of low-MCA player-types (Capital) free-ride in the baseline treatment (contribute zero tokens). Free-riding increases in the communication treatment, with 26.4% of capital-players contributing nothing towards public good provision. A McNemar Chi-square test indicates there to be no statistically significant difference in the proportion free-riding in these two treatments (p = 0.248), however. Furthermore: 71.4% of Capital players who free-ride in the baseline treatment, continue to free-ride in the communication treatment.

Table 9: Frequency distributions of contributions (Sequence 2 and 3)

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

With regard to high-MCA player-types (Labour), 33.8% free-ride in the baseline treatment, increasing significantly to 45.6% in the communication treatment (McNemar Chi-square test: p = 0.033). In addition: around 87% of labour players who free-ride in the baseline treatment continue to do so in the communication treatment.

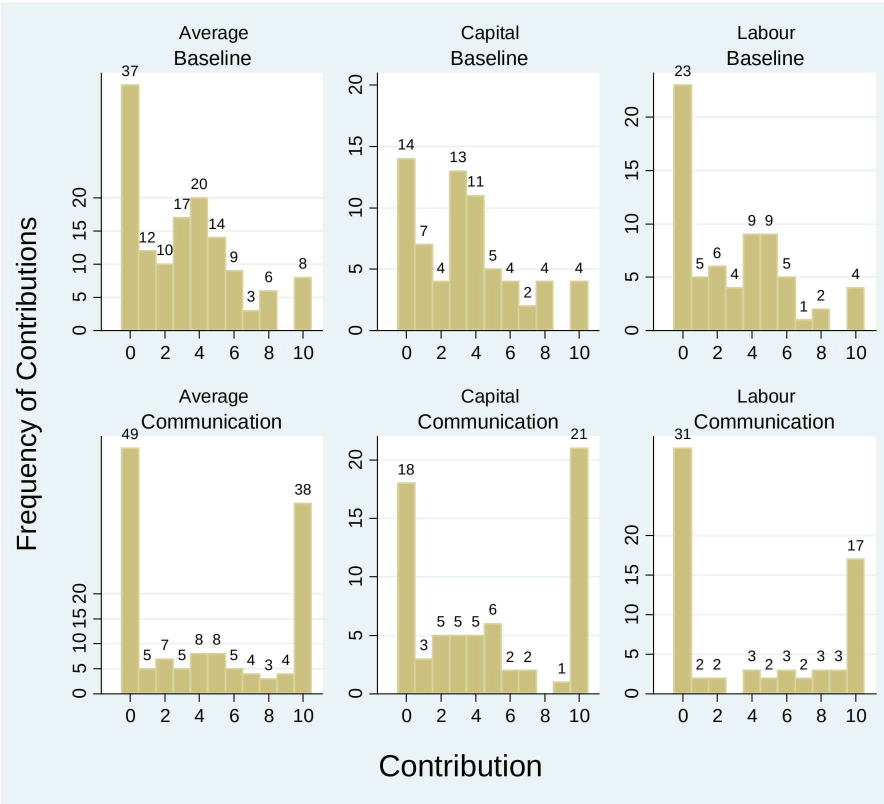
Observation 7: The prevalence of perfect cooperation increases significantly amongst both low and high-MCA player-types when players are able to communicate

While communication is insufficient in encouraging participation for some, it is an effective mechanism for others. This is particularly visible in the increased number of participants who contribute their total endowment to reducing emissions (perfect cooperation). The percentage of capital players contributing 10 tokens to the public good increased significantly from 5.9% in the baseline treatment to 30.9% with communication (McNemar Chi-square test: p = 0.000). Labour also shows a marked increase in cooperation with the introduction of communication – with the number of participants contributing 10 tokens increasing from 5.9% to 25% (MacNemar Chi-square test: p = 0.002).

Observation 8: Observations 5, 6 and 7 lead to a greater polarisation of contributions and dual norms of free-riding and perfect cooperation; communication in a heterogeneous-group setting has increased inequality rather than engendering a sense of shared responsibility

What is remarkable about the combinations of the previous two results is the polarisation it causes (as can be observed in Figure 4 which reflects the distribution of contributions for the pooled baseline and communication treatments). Starting with low-MCA player-types (Capital), in the baseline treatment, 26.5% of Capital-types contribute either 0 *or* 10 tokens to the public good; this increases to 57.3% in the communication treatment. With respect to labour, 39.7% of labour-players contribute either 0 *or* 10 tokens in the baseline treatment, increasing to 70.6% in the communication treatment. When considering an average across player-types, in the baseline treatment, 33.1% of both Capital and Labour players contributed either 0 *or* 10 tokens, as compared to 64.0% in the communication treatment. Thus, the communication treatment is dominated by two seemingly opposing norms – free-riding or perfect cooperation.

Figure 4: Contributions, Sequence 2 and 3



The difficulty with a result like this is the seeming lack of a middle ground. While there are some who are more than willing to cooperate fully (and so reach the maximum level of emission reductions), there are others who are equally willing to exploit probable cooperation for personal monetary gain. Thus, despite the view that communication is a tool to facilitate a shared sense of responsibility, in this instance, communication has increased inequality. Given the divergence of our finding from the results summarised by Sally (1995), it seems reasonable to assume that the polarisation we have observed is, at least in part, a product of the heterogeneity of the participants involved.

3.3.3. Emission reductions and player type

Although the results reported thus far have taken cognisance of the different types of players involved, this has been done in order to examine the general effect of communication. Differences between the two types of players and the way in which the 'dual-norm effect' manifests itself in each have not been examined.

Observation 9: There is a significant relationship between free-riding and player type: players with a higher marginal cost of abatement (labour-players) are more likely to free-ride, especially after communication.

Using a Chi-square test, we find that the relationship between player-type and free-riding in the baseline treatment is non-significant (p = 0.083), however, this relationship becomes highly significant in the communication treatment (Chi-square test: p = 0.020). This result confirms the previous finding that the prevalence of free-riding among high-MCA player-types (Labour) increases significantly with the introduction of communication (Observation 6).

Observation 10: The tendency of players to contribute their full endowment is independent of differences in marginal abatement costs (player-types).

While Labour players free-ride more than Capital players, we do not see a similar differentiation with respect to perfect cooperation. 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 outcome was expected given the previous finding that the prevalence of perfect cooperation increases significantly amongst both low and high-MCA player-types with communication (Observation 7). Thus, the propensity to contribute ones full endowment to public good provision is independent of player-type.

Observation 11: Observations 9 and 10 provide additional evidence for the finding that communication increases rather than decreases inequality: Observation 9 reveals that inequality is increased across player-types; Observation 10 supports the finding in Observation 8 that inequality is also present within player-types

Observation 9 indicates that there are significant differences in the cooperation rates of the two different player-types: specifically, high-MCA player-types (Labour) are more likely to free-ride relative to low-MCA player-types (Capital). On the other hand, Observation 10 implies a lack of differentiation at the other pole of the histogram which allows for the emergence of the 'dual-norm effect' observable in the contributions made by both Capital and Labour players, culminating in increase in inequality that is not player-type specific.

Combining these two results implies that communication in a heterogeneous-setting both increases inequality across player-types and within a particular player-type.

4. Discussion and conclusion

As the limited success of recent multilateral climate negotiations continues to make clear, international agreement on climate-change mitigation is one of the biggest challenges facing the global community. The concept of a 'shared but differentiated responsibility' and the ensuing questions of fairness around the distribution of the abatement burden are central themes within the climate change debate. These fairness considerations are equally relevant in a national context where government has specified a national emission reduction target. Within a national context, stakeholder participation (proxied in this experiment design by the introduction of communication) is often seen as an important mechanism with which to achieve both a fair and equitable distribution of the mitigation burden.

The experiment ultimately considers the effect of communication in facilitating public good provisions within a heterogeneous-setting. While it is a priori unclear as to what contributions norms might arise when players are heterogeneous, the climate change framing exacerbates equity considerations and ultimately increases the difficulty of finding a generalizable concept of fairness (contribution norm) acceptable to both player-types.

When agreements are non-binding (and talk is cheap), participants in a public good setting such as this are expected to use communication as a tool to elicit cooperation from others, while then free-riding themselves – rendering communication ineffective in facilitating public good provision. Yet, evidence from the lab suggests that communication significantly increases cooperation. In this study, during the online chat, a majority of groups advocated and voted for a contribution norm of equality of income – requiring all group members to contribute their full endowment to the public good (mitigation). It is likely this norm was considered the most simple and fair within the heterogeneous setting of the experiment.

Our results tentatively suggest that communication increases cooperation relative to the status quo (baseline). Furthermore, communication does facilitate greater success in terms of meeting the national emission reduction target. However, the results also provide evidence in favour of the above theoretical adage (for at least some of the participants), whereby communication is used as a mechanism to convince others to cooperate while free-riding yourself. Not only did communication not induce free-riders to cooperate, but the frequency of free-riding among high-MCA players increased significantly with the introduction of communication. Communication did facilitate greater cooperation in both player-types, however, with the frequency of perfect cooperation increasing significantly for both player-types with the onset of communication. Given these findings, the introduction of communication exacerbated the polarisation between free-riders and perfect cooperators; a polarisation found in both player types. The presence of these two dominant contributions norms – namely, that of free-riding and perfect cooperation, has served to increase inequality. As such, in a heterogeneous setting, the efficacy of communication in greatly reduced.

As previously mentioned, the frequency of free-riding among high-MCA player-types (Labour) increased with communication. Within a climate-change context, this suggests that individuals facing a high marginal cost of abatement and low levels of historical responsibility consider the responsibility for mitigation to lie with those individuals who have a low marginal cost of abatement and high levels of historical responsibility. This suggests that high-MCA players endorse the polluter-pays rule – the burden-sharing principle often advocated by developing-countries during global climate negotiations.

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Appendix A

Auxiliary regressions, Sequence 2 and Sequence 2

	(1)	(2)
Variables	*(Baseline & Comm.) (K players)* *(Sequence 2)*	*(Baseline & Comm.) (K players)* *(Sequence 3)*
Sequence	-	-
	-	-
Session	0.598	1.927*
	(0.904)	(1.038)
Comm.	0.706	1.941***
	(0.532)	(0.677)
Capital	-	-
	-	-
Female	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.*

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The Southern Africa Labour and Development Research Unit (SALDRU) conducts research directed at improving the well-being of South Africa's poor. It was established in 1975. Over the next two decades the unit's research played a central role in documenting the human costs of apartheid. Key projects from this period included the Farm Labour Conference (1976), the Economics of Health Care Conference (1978), and the Second Carnegie Enquiry into Poverty and Development in South Africa (1983-86). At the urging of the African National Congress, from 1992-1994 SALDRU and the World Bank coordinated the Project for Statistics on Living Standards and Development (PSLSD). This project provide baseline data for the implementation of post-apartheid socio-economic policies through South Africa's first non-racial national sample survey.

In the post-apartheid period, SALDRU has continued to gather data and conduct research directed at informing and assessing anti-poverty policy. In line with its historical contribution, SALDRU's researchers continue to conduct research detailing changing patterns of well-being in South Africa and assessing the impact of government policy on the poor. Current research work falls into the following research themes: post-apartheid poverty; employment and migration dynamics; family support structures in an era of rapid social change; public works and public infrastructure programmes, financial strategies of the poor; common property resources and the poor. Key survey projects include the Langeberg Integrated Family Survey (1999), the Khayelitsha/Mitchell's Plain Survey (2000), the ongoing Cape Area Panel Study (2001-) and the Financial Diaries Project.

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