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ERSA working paper 298

http://econrsa.org/home/index.php?option=com_docman&task=doc_download&gid=442&Itemid=67

July 2012

Economic Research Southern Africa (ERSA) is a research programme funded by the National Treasury of South Africa.

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July 5, 2012

Abstract

The lack of cooperation and prevalence of free riding in efforts to reduce emissions reflects the public good dilemma synonymous with climate change: whereby individual incentives lead to sub-optimal outcomes. This study examines how cooperative norms can be fostered through democratic processes. Specifically, we assess whether a given policy affects cooperation more significantly when it is democratically chosen by heterogeneous subjects as opposed to exogenously imposed by the experimenter. Subjects with differing marginal costs of abatement must democratically select an institution to reduce a national greenhouse gas inventory. By majority vote, subjects can choose between communication and two carbon tax variants. The experimental literature from studies with homogenous subjects suggests that cooperation improves when policy is endogenously selected as opposed to exogenously enforced. Overall we find that endogenous choice does not improve cooperation when subjects are heterogeneous. Furthermore, we find that, in the absence of a binding commitment, cooperation declines with endogenous choice as the prevalence of free-riding increases.

Key words: heterogeneity; voting; communication; public good

1 Introduction

The nature of a public good dilemma like climate change mitigation is that what is rational for the individual results in a collectively suboptimal outcome. While there is a large experimental literature confirming that public good provision is improved with the introduction of peer punishment, communication and voting (Fehr and Fischbacher, 2004; Gächter and Herrmann, 2009), much of this

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†Financial support from Economic Research Southern Africa (ERSA), the Swedish International Development Cooperation Agency (Sida) – through the Environment for Development (EfD) initiative, and the FORMAS program COMMONS is gratefully acknowledged.

literature is framed around agents with symmetric interests. However social dilemmas, such as climate change, are often characterised by heterogeneous-group environments. For example, global and national climate change dialogues require countries and individuals with wealth and historical emission disparities to collectively meet an abatement target. In this context it is not surprising that equity and distributive fairness considerations have been important subtexts in global and national climate change debates. As climate change is the ultimate example of agents with asymmetric interests acting for the collective, this study uses a public good experiment with voting and a climate change framing to consider both public good provision and institutional choice among players with asymmetric interests.

Recent experimental studies have found behavioural differences between homogenous and heterogeneous groups:

For example, while experimental evidence from public good games with homogeneous players reflects the norm of equal contributions (Fehr and Fischbacher, 2004; Gächter and Herrmann, 2009; Reuben and Riedl, 2009), it is not clear what contribution norm arises when players have asymmetric interests (Anderson *et al.* 2004; Buckley and Croson, 2006; Cherry *et al.*, 2005; Hofmeyr *et al.*, 2007; Rappoport and Suleiman 1993;Visser and Burns, 2006).

Experimental evidence from studies with *homogenous* players suggests that voting improves public good provision, with the caveat that voting is coupled with third-party enforcement or endogenous punishment (Ertan et al., 2009; Kroll et al., 2007; Sutter et al.; 2010; Tyran and Feld, 2006; Walker et al. 2000). Tyran and Feld (2006) argue that a voting process creates an expectation of cooperative behaviour which induces compliance; and this notion of conditional cooperation is widely supported by the experimental evidence (Fehr and Fischbacher, 2004; Fischbacher et al., 2001; Gächter and Herrmann, 2009). However, in the absence of enforcement or punishment, voting often represents an empty commitment. Kroll et al. (2007) find that in the absence of a punishment or enforcement mechanism, contributions in a public-good-with-voting game are similar to levels seen in the standard public good game. However, when punishment is introduced, contributions are equivalent to those under third-party enforcement. The authors conclude that voting is little more than cheap talk in the absence of an enforcement mechanism. Our results indicate that in the absence of punishment or other enforcement mechanism, cooperation actually declines with voting. When voting is coupled with third party enforcement, contributions levels are equivalent to those seen in the corresponding endogenous treatment.

Players with symmetric interests also more easily self-select into the same endogenous punishment institutions. In the experiment of Gürerk et al. (2006), players periodically decide whether to participate in a public good game with or without sanctioning opportunities. While the majority of players initially self-select into the sanction-free institution, all players eventually select the sanctioning institution. Ertan *et al.* (2009) allow subjects to periodically vote on whether to punish below-average, average and above-average contributors. While the authors observed a reluctance to vote for punishment at the outset, voting behaviour conformed to the most efficient institution of punishing below-average contributors.

For players with asymmetric interests, the task of choosing an institution to promote cooperation is made more difficult. Noussair and Tan (2011) introduce heterogeneity into Ertan et al.'s (2009) design by varying subjects' MPCRs *to* the public good: each group consists of high and low-MPCR players. While the most effective institution is one allowing for the punishment of below-average contributors regardless of player-type, this punishment institution is seldom adopted as subjects' are more likely to vote for a punishment rule that pertains to a different player-type. The authors conclude that the introduction of heterogeneity into a public-good-with-voting framework hampers the establishment of optimal punishment institutions. Margreiter et al. (2005) analyse the effect of heterogeneity in a common pool resource problem and find that heterogeneous groups are less likely to reach agreement through a voting process.

The experiment consists of 5 treatments. In the first 4 treatments, the institutions governing behaviour are exogenously determined by the experimenters. These treatments include the standard public good game, a communication treatment and two tax treatments. The final treatment is one where the governing institution is endogenously determined through a voting process during which subjects vote for the institution they want to see implemented as the final treatment. As will become clear when the experimental design is discussed, *voting for the tax treatments essentially amounts to voting for third-party enforcement, whereas by voting for the communication treatment, subjects are casting a non-binding vote.*

The results of the exogenous treatments are discussed in Brick and Visser (2010). This study analyses the voting treatment and considers whether voting improves public good provision among heterogeneous players.

The paper proceeds as follows: Section 2 outlines the experiment design and framing, while the experiment results are described in Section 3. Section 4 concludes with a discussion.

2 Experiment design

The experiment design is summarized below. For a more detailed description, the reader is referred to Brick and Visser (2010).

2.1 Baseline treatment

The experiment examines the cooperative behaviour of different player-types in reducing a national greenhouse gas inventory. Players differ in terms of their *marginal abatement costs* – with each group consisting of two players with a low marginal cost (MC) of abatement and two players with a high MC of abatement. In terms of the framing, when entering the lab, subjects were allocated a specific factor of production, namely capital (firms) or labour (households); capital players have a low MC of abatement while labour players have high marginal abatement costs.[1]

In the *baseline* treatment, participants are each endowed with 10 tokens which can be allocated between a private and public account. Contributions to the public account reflect investments in mitigation. Equations 1 and 2 signify subjects' payoffs, where c_{L_i} and c_{H_i} signify investments in the public good (mitigation) by low MC of abatement player-types and high MC of abatement player-types, respectively. Contributions to the private account represent investment opportunities other than investing in mitigation. We assume that capital (low MC of abatement player-types) earn a higher return from money invested in the private account relative to labour. As evident from equations 1 and 2 one token contributed to the private account by the low MC of abatement player-type (high MC of abatement player-type) generates a private return of 12 tokens (6 tokens).

$$\pi_{L_i} = 12(10 - c_{L_i}) + 0.25(20 \times \sum_{i=1}^{2} c_{L_i} + 10 \times \sum_{i=1}^{2} c_{H_i}) \tag{1}$$

$$\pi_{H_i} = 6(10 - c_{H_i}) + 0.25(20 \times \sum_{i=1}^{2} c_{L_i} + 10 \times \sum_{i=1}^{2} c_{H_i}) \tag{2}$$

Because players differ in their marginal abatement costs, marginal contributions *to* the public account are *asymmetric*. Specifically, players with a low marginal cost of abatement are able to reduce more emissions with one token relative to players with a high marginal abatement cost. Thus, each token invested by a low MC of abatement player-type in mitigation makes a larger *marginal contribution* to the public good relative to a token invested by a high MC of abatement player. Contributions to the public account by players with a low and high MC abatement costs are therefore multiplied by 20 and 10, respectively (equations 1 and 2) Appendix A illustrates the emission reduction achieved by each player-type for different token-investments in mitigation.

As everyone benefits equally from mitigation, the tokens invested in mitigation are distributed equally amongst the four group members – irrespective of their individual contributions. As such, one token invested in the public account by players with a low and high MC of abatement generates a return for *each* group member of 5 and 2.5 tokens, respectively. Notably, for both player-types, the marginal per capita return (MPCR), which is the ratio between the marginal value of a token invested in mitigation and the marginal value of a token invested in the private account, is 0.42. Thus the MPCR from investing in mitigation is the same for all players, again indicating that players derive the same benefit from mitigation.

[1] It is important to emphasise that while the experimental framing specifically refers to capital and labour, the experiment design is applicable in any context where marginal abatement costs differ (for example, two firms or two households with differing marginal costs of abatement).

In terms of the framing, participants are told that government has set a national emission reduction target in line with its multilateral obligations. As the setting of a national target forms part of a multilateral commitment to reduce emissions (such as an international environmental agreement like the Kyoto Protocol), the return from mitigation quantifies the benefit of a decrease in the risks related to climate change, such as a decrease in the likelihood of environmental disaster.[2] An explicit reduction *target of 240 units* was specified. As illustrated in Appendix A, this target can be met via both player-types contributing different combinations of tokens to the public good. In the baseline treatment, the target was not binding, but government's commitment to meeting the target was emphasised.

As the public return is less than the private return for both player-types, the dominant strategy for both player-types is to contribute nothing towards mitigation whereas the social optimum is achieved when all players contribute their full endowment to mitigation.

As mentioned previously, the baseline treatment is extended by way of four additional treatments. These are outlined below.

2.2 Communication treatment

The communication treatment is identical to the baseline treatment except that participants can communicate with their group members via an online chat program in order to decide, as a group, how best to meet the target. The group consensus is not binding, however, and players are free to decide on their own contribution levels.

As in the baseline treatment, the national emission reduction target was emphasised to players but was not binding.

2.3 Carbon tax treatment: uniform tax

Note:

1. *Both player-types are required to reduce emissions equally*
2. *Non-compliance is sanctioned*

In this treatment, both player-types must reduce emissions *equally* – irrespective of the difference in marginal abatement costs. To meet the (now binding) target of reducing emissions by 240 units, all 4 group members must reduce emissions by 60 units each (Appendix A). As evident from Appendix A, this means that low MC of abatement players must contribute 3 tokens to the public account while players with a high MC of abatement must contribute 6 tokens to the public account. We refer to this treatment as *tax36*.

[2] Furthermore, assuming mitigation actions result in a reduction in electricity usage, in countries with low electricity reserve margins and a focus on demand side management in the electricity sector, the returns from mitigation would also include a reduction in the probability of black-outs amid reduced peak consumption.

Players are fined ten tokens per token below the specified minimum contribution level. As such, the Nash equilibrium is moved inwards to 3 (6) for low MC of abatement (high MC of abatement) player-types.

Subjects' payoffs are now given by:

$$\pi_{L_i} = 12(10 - c_{L_i}) + 0.25(20 \times \sum_{i=1}^{2} c_{L_i} + 10 \times \sum_{i=1}^{2} c_{H_i}) if c_{L_i} \geq 3 \tag{3}$$

$$\pi_{L_i} = 12(10 - c_{L_i}) + 0.25(20 \times \sum_{i=1}^{2} c_{L_i} + 10 \times \sum_{i=1}^{2} c_{H_i}) - (10 \times (3 - c_{L_i})) if c_{L_i} < 3 \tag{4}$$

$$\pi_{H_i} = 6(10 - c_{H_i}) + 0.25(20 \times \sum_{i=1}^{2} c_{L_i} + 10 \times \sum_{i=1}^{2} c_{H_i}) if c_{H_i} \geq 6 \tag{5}$$

$$\pi_{H_i} = 6(10 - c_{H_i}) + 0.25(20 \times \sum_{i=1}^{2} c_{L_i} + 10 \times \sum_{i=1}^{2} c_{H_i}) - (10 \times (6 - c_{H_i})) if c_{H_i} < 6 \tag{6}$$

2.4 Carbon tax treatment: differential tax

Note:

1. *Players are required to split the (token) cost of reducing emissions equally among themselves*
2. *Non-compliance is sanctioned*

While player-types can reduce emissions by different quantities, they must contribute the same number of tokens to mitigation. If all group members contribute 4 tokens to mitigation, the group will collectively meet the emission reduction target of 240 (see appendix A).Low MC of abatement players are now reducing emissions by 80 units while high MC of abatement players are reducing emissions by 40 units. We call this treatment *tax44*.

Once again players are fined ten tokens for every token below the specified minimum contribution level and the Nash equilibrium is moved inwards to 4 tokens for all player-types.

$$\pi_{L_i} = 12(10 - c_{L_i}) + 0.25(20 \times \sum_{i=1}^{2} c_{L_i} + 10 \times \sum_{i=1}^{2} c_{H_i}) if c_{L_i} \geq 4 \tag{7}$$

$$\pi_{L_i} = 12(10 - c_{L_i}) + 0.25(20 \times \sum_{i=1}^{2} c_{L_i} + 10 \times \sum_{i=1}^{2} c_{H_i}) - (10 \times (4 - c_{L_i})) if c_{L_i} < 4 \tag{8}$$

$$\pi_{H_i} = 6(10 - c_{H_i}) + 0.25(20 \times \sum_{i=1}^{2} c_{L_i} + 10 \times \sum_{i=1}^{2} c_{H_i}) if c_{H_i} \geq 4 \tag{9}$$

$$\pi_{H_i} = 6(10 - c_{H_i}) + 0.25(20\times\sum_{i=1}^{2} c_{L_i} + 10\times\sum_{i=1}^{2} c_{H_i}) - (10 \times (4 - c_{H_i})) if c_{H_i} < 4 \tag{10}$$

2.5 Voting treatment

Subjects are given the opportunity of voting for either the communication treatment or one of the tax treatments. The treatment receiving the majority share of votes (by all experiment participants) is repeated in the final round as the last treatment.

2.6 Sample and procedures

The experiment was conducted with 204 students from the University of Cape Town (UCT), South Africa. Over 60% of subjects were male and, on average, subjects were 21 years old. A broad spectrum of faculties was represented, including: commerce, humanities and the built environment.

The treatments and sequencing are outlined in Table 1. The experiment consisted of three sequences: *Sequence 1* (Baseline$_1$, Baseline$_2$, Baseline$_3$, Baseline$_4$, Baseline$_5$); *Sequence 2* (Baseline, Comm., Tax$_{36}$, Tax$_{44}$, Voting, endogenous Tax$_{44}$); *Sequence 3* (Baseline, Tax$_{44}$, Tax$_{36}$, Comm., Voting, endogenous Comm.). *Each* sequence was completed over 2 *sessions (Session 1 and Session 2)* and consisted of a sample of 68 subjects.

As evident from Table 1, in the first four treatments the governing institutions were exogenously imposed by the experimenter. In Sequences 2 and 3, after completion of the fourth treatment, subjects were asked to vote on which treatment they would like to play again as the final treatment of the session. The treatment which was voted for by the majority of players was played as treatment 5. *Before making their decisions*, roughly half the participants in each sequence were provided with payoff feed-back for each treatment.

3 Experimental results

Mann-Whitney tests can't reject the null hypothesis that the contributions in the *Session 1* and *Session 2* of ***each*** sequence are drawn from the same distribution ($p > 0.110$ for all sequences). As such, when discussing the experimental results for each treatment, we pool the data from Session 1 and Session 2 in each sequence..

3.1 Institutional preference

Observation 1: Subjects' institutional preference is split equally between third-party enforcement (tax) and a non-binding vote (communication).

In Sequence 2, around 52% of subjects voted for tax44[3], while 25% voted for communication and 23.5% voted for tax36[4]. Given the majority vote, tax44 was repeated as the fifth treatment in this sequence. In Sequence 3, 56% of subjects voted for communication, 29% voted for tax44 and 15% voted for tax36. Given the majority preference, communication was repeated as the fifth treatment in Sequence 3. When considering the entire sample, the communication and tax44 treatments both received approximately 40% of the votes, while around 19% of subjects voted for tax36. The outright preference for tax44 over tax36 (in both sequences) implies that the participants don't expect players with different abatement costs to reduce emissions equally.

Subjects in *Session* 1 of Sequence 2 and Sequence 3 received payoff-feedback before casting their vote (Table 1). However, payoff feed-back significantly impacted on voting behaviour in Sequence 3 only (Chi-square tests: Sequence 2: $p = 0.286$; Sequence 3: $p = 0.039$).

There is also evidence of ordering effects on subjects' voting behaviour in the two sequences (Chi-square test: $p = 0.001$). Given the ordering effects, when discussing the results, we pool the data from both *sessions* in each sequence (as discussed), but will discuss Sequence 2 and Sequence 3 separately (this is the logical approach in any event given that the endogenous treatments differ in the two sequences).

It would therefore seem that subjects voting choices were determined by a combination of things including: equity considerations, payoff feed-back in the case of Sequence 3 and ordering effects (opting to repeat the treatment they are most recently familiar with).

3.2 Sequence 2 (vote for third-party enforcement: tax44)

Table 2 reflects participants' contributions in *Sequence 2* for the baseline, exogenous tax44 and endogenous tax44 treatments.

3.2.1 Average contributions

Observation 2: The introduction of the tax improves cooperation relative to the baseline; but cooperation does not significantly differ between the exogenous and endogenous tax treatments

Observation 3: In the tax treatments, players with a high MC of abatement contribute more to public good provision than players with a low MC of abatement

Wilcoxon signed-rank tests confirm that, for both player-types, average contributions (Table 2, panel A) in both the exogenous and endogenous tax treatments are significantly higher than those in the baseline treatment (for both player-types: $p < 0.01$ for both exogenous and endogenous tax44 treatments

[3] Equal cost for both player-types of reducing emissions; unequal emissions reductions with the low MC of abatement player reducing more emissions

[4] Equal emissions reductions; unequal emission reduction costs with the cost of mitigation being higher for the player with the high MC of abatement

relative to baseline). However, for both-player types, average contributions in the endogenous and exogenous tax treatments do not differ significantly (low MC of abatement payer: $p = 0.400$; high MC of abatement player: $p = 0.773$).

When comparing the two player-types, Mann-Whitney tests confirm that contributions in the baseline treatment do not differ significantly by player-type ($p = 0.690$). However, players with a high MC of abatement contribute, on average, significantly more than players with a low MC of abatement in *both* the exogenous and endogenous tax44 treatments (Mann-Whitney tests: exogenous tax44 treatment: $p = 0.032$; endogenous tax44 treatment: $p = 0.029$).

3.2.2 Frequency of perfect cooperation

Observation 4: Perfect cooperation does not significantly differ between the exogenous and endogenous tax treatments

Observation 5: The frequency of perfect cooperation does not differ by player-type

Panel B in Table 2 reflects the frequency of contributions of all *ten tokens* in the baseline and tax treatments, for both player-types. Subjects that contribute their full endowment are considered to be *perfect cooperators.*

For the low MC of abatement player-type, the frequency of perfect cooperation does not increase significantly in either tax treatments relative to the baseline treatment (McNemar test: $p > 0.500$ for both tax treatments vs. baseline). A comparison of the extent of perfect cooperation in the exogenous and endogenous tax44 treatments is similarly insignificant (McNemar test: $p = 0.317$).

Likewise, for the low MC of abatement player-type, the frequency of perfect cooperation does not significantly increase in the exogenous and endogenous tax44 treatments relative to the baseline treatment (McNemar test: $p > 0.150$ for both tax treatments vs. baseline). Furthermore, voting does not increase the frequency of perfect cooperation (McNemar test: exogenous tax44 vs. endogenous tax44: $p = 0.655$).

Does the frequency of perfect cooperation differ by *player-type*? Player heterogeneity has no significant impact on the frequency of perfect cooperation in the baseline, exogenous tax44 and endogenous tax44 treatments (Fisher's exact test: $p > 0.600$ for all treatments).

3.2.3 Frequency of contributions greater than the Nash equilibrium

Observation 6: The frequency of contributions exceeding the Nash equilibrium do not differ significantly between the exogenous and endogenous tax treatments for both player-types

Observation 7: In the tax treatments, players with a high MC of abatement contribute more than the Nash equilibrium with greater frequency than players with a low MC of abatement

Panel C in Table 2 reflects the frequency of contributions of greater than 4 tokens – which in the tax44 treatment, signify contributions *in excess of the Nash equilibrium.*

Players with a low MC of abatement contributed 5 or more tokens 21% of the time in the baseline treatment as compared to 24% in the exogenous tax treatment (McNemar test: $p = 0.706$) and 18% in the endogenous tax treatment (McNemar test: $p = 0.655$). As evident by the McNemar tests, these differences are not significant. Similar results are obtained when comparing the exogenous tax treatment to the endogenous tax treatment (McNemar test: $p = 0.157$).

Players with a high MC of abatement contributed 5 or more tokens 32% of the time in the baseline treatment as compared to 47% in the exogenous tax treatment and 38% in the endogenous tax treatment; however, these differences are not significant: McNemar test: baseline vs. exogenous tax44: $p = 0.197$; baseline vs. endogenous tax44: $p = 564$. Furthermore, cooperative behaviour beyond the Nash equilibrium does not differ between the exogenous and endogenous tax44 treatments (McNemar test: $p = 0.180$).

When comparing player-types, a Chi-square test indicates there to be no significant difference between contributions of high and low types in the baseline treatment ($p = 0.272$). However, similar comparisons for exogenous tax44 (Chi-square test: $p = 0.042$) and endogenous tax44 (Chi-square test: $p = 0.059$) treatments are significant, indicating that, for both these treatments, players with a high MC of abatement contribute greater than the Nash equilibrium with greater frequency than players with a low MC of abatement.

3.3 Sequence 3 (non-binding vote for communication)

Table 3 reflects participants' contributions in *Sequence 3* for the baseline and exogenous and endogenous communication treatments.

As mentioned in Section 2, in the communication treatment, participants communicate with their group members via an online chat program and decide, as a group, how best to meet the target. During the group discussions in both the exogenous and endogenous communication treatments, the consensus in the majority of groups was for each group member to contribute their full endowment. However, as mentioned previously, this group consensus was not binding, leaving players to decide on their own contribution levels.

3.3.1 Average contributions

Observation 8: A non-binding vote for communication does not improve cooperation relative to the baseline or exogenous communication treatments for both player-types.

Observation 9: payers with a low MC of abatement contribute more, on average, than players with a high MC of abatement in the exogenous communication treatment; contributions do not differ by player type in the endogenous communication treatment

Panel A in Table 3 reflects the average contributions of both player-types in the baseline and exogenous and endogenous communication treatments in Sequence 3.

For players with a low MC of abatement, an average contribution of 5.95 tokens in the exogenous communication treatment is significantly higher than that of the baseline treatment (Wilcoxon signed-rank test: $p = 0.014$). However, average contributions of 4.24 in the endogenous communication treatment do not differ significantly to that of the baseline treatment (Wilcoxon signed-rank test: $p = 0.580$). Finally, average contributions in the exogenous communication treatments are significantly higher relative to average contributions in the endogenous communication treatment (Wilcoxon signed-rank test: $p = 0.018$).

Wilcoxon signed-rank tests confirm that, for players with a high MC of abatement, average contributions in the exogenous and endogenous communication treatments do not differ significantly to those in the baseline ($p > 0.200$ for both communication treatments vs baseline). Furthermore, average contributions in the exogenous communication treatment do not differ significantly to those in the endogenous communication treatment (Wilcoxon signed-rank test: $p = 0.358$).

Mann-Whitney tests indicated there to be no significant difference between the average contributions of the two player-types in the baseline ($p = 0.3452$) and endogenous communication ($p = 0.382$) treatments. However, players with a low MC of abatement contribute, on average, significantly more than players with a high MC of abatement in the exogenous communication treatment ($p = 0.054$).

3.3.2 Frequency of contributions of free riding

Observation 10: Players with a low MC of abatement free ride more frequently in the endogenous communication treatment relative to the baseline and exogenous communication

Observation 11: Players with a high MC of abatement free ride more frequently in the endogenous communication treatment relative to the baseline treatment

Observation 12: Free-riding does not differ significantly by player-type in the endogenous communication treatment

Panel B in Table 3 reflects the frequency of free-riding - contributions of *zero tokens* – in the baseline and exogenous and endogenous communication treatments, for both player-types.

For players with a low MC of abatement, the frequency of free -riding does not differ significantly when comparing the baseline to exogenous communication (McNemar test: $p = 0.706$). However, relative to the baseline treatment, the frequency of free-riding does significantly increase with endogenous communication (McNemar test: $p = 0.058$). Furthermore, the frequency of free riding is significantly higher in the endogenous communication treatment relative to exogenous communication (McNemar test: $p = 0.059$).

Players with a high MC of abatement free ride with greater frequency in the exogenous and endogenous communication treatments relative to the baseline (exogenous communication vs. baseline: McNemar test: $p = 0.096$; exogenous communication vs. baseline: McNemar test: $p = 0.008$). Finally, a comparison of the frequency of free-riding in the exogenous and endogenous communication treatments is insignificant (McNemar test: $p = 0.317$).

Neither player-type free-rides with greater frequency in the baseline treatment (Chi-square test: $p = 0.161$). However, when comparing free-riding in the exogenous communication treatment by player-type, we find that players with a high MC of abatement free-ride with significantly greater frequency (Chi-square test: $p = 0.021$). Lastly, free-riding does not differ significantly by player-type in the endogenous communication treatment (Chi-square test: $p = 0.143$).

3.3.3 Frequency of perfect cooperation

Observation 13: For players with a low MC of abatement, perfect cooperation is more frequent in the exogenous communication treatment relative to endogenous communication and the baseline

Observation 14: For players with a high MC of abatement, the frequency of perfect cooperation increases with endogenous communication relative to the baseline

Observation 15: The frequency of perfect cooperation does not differ by player-type

For players with a low MC of abatement, perfect cooperation is more prevalent in the exogenous communication treatment (McNemar test: $p = 0.001$) and endogenous communication treatment (McNemar test: $p = 0.058$) relative to the baseline. Furthermore, the frequency of perfect cooperation is significantly less in the endogenous communication treatment relative to exogenous communication (McNemar test: $p = 0.083$).

The frequency of perfect cooperation for high-types increases significantly with exogenous communication (McNemar test: $p = 0.058$) and endogenous communication (McNemar test: $p= 0.034$) relative to the baseline treatment. Furthermore, a comparison of the frequency of perfect cooperation in the exogenous and endogenous communication treatment is insignificant (McNemar test: $p = 1.000$).

The frequency of perfect cooperation does not differ by player-type in the baseline, exogenous communication or endogenous communication treatments (Chi-square tests: $p > 0.120$ for all treatments.

4 Discussion

We have used a framed public good game to assess whether endogenous institutional choice enhances cooperative behaviour among asymmetric agents. After a series of exogenously imposed treatments, subjects voted for the treatment they wanted to see implemented. Subjects choose between a communication treatment, a carbon tax design which specified equal emissions reduction and unequal contributions to the public good (tax36), or a carbon tax which specified equal contributions to the public good and unequal emission reductions (tax44).

Our first finding relates to how cooperative behaviour is affected when a given institution is endogenously selected within a heterogeneous-group environment. With respect to democratic choice, subjects favour stakeholder participation (communication treatment) and a carbon tax equally. This was surprising given that we assumed *a priori* that subjects would not select an institution that enables subjects to free ride (Kosfeld 2009)

Results for the tax treatment show no difference in cooperation with the introduction of voting. Specifically, (i) average contributions, (ii) the frequency of perfect cooperation and (iii) the frequency of contributions in excess of the Nash equilibrium do not differ significantly between the exogenous and endogenous treatments, for both high and low MC of abatement players. When comparing the different player-types, we see that players with a high MC have significantly higher average contributions and contribute more than the Nash equilibrium with greater frequency relative to players with a low MC of abatement – but this is the case for *both* the exogenous and endogenous tax treatments.

In the communication treatment, for players with a low MC of abatement, amid the lack of enforcement mechanism, cooperation actually declines with the introduction of voting: average contributions are lower and the incidence of free riding is higher in the endogenous communication treatment relative to the exogenous treatment; in addition, the frequency of perfect cooperation declines with endogenous communication when compared to exogenous communication. For players with a high MC of abatement, average contributions and the frequency of free riding and perfect cooperation in the exogenous and endogenous communication treatments do not differ significantly. Kroll et al. (2007) similarly find that without the application of punishment to enforce cooperation, voting is simply an empty commitment. Furthermore, Kosfeld (2009) also find that in the absence of a binding commitment, cooperation is difficult to achieve. When comparing player-types, there is no significant difference between average contributions, the incidence of perfect cooperation and the frequency of free riding of low and high MC of abatement players in the endogenous communication treatment.

These results indicate that in a heterogeneous environment, endogenous institutional choice does not improve public good provision. While cooperation was at least unchanged when subjects voted for third party enforcement (tax treatment), cooperation actually declined when subjects voted for communication as the lack of enforcement mechanism allowed them to deviate from the group consensus.

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Table 1: Experiment overview

Determination	Treatment	Sequence 1		Sequence 2		Sequence 3	
		Session 1 *n=36*	Session 2 *n=32*	Session 1 *n=32*	Session 2 *n=36*	Session 1 *n=36*	Session 2 *n=32*
Exogenous	Treatment 1	Baseline_1	Baseline_1	Baseline	Baseline	Baseline	Baseline
Exogenous	Treatment 2	Baseline_2	Baseline_2	Comm.	Comm.	Tax44	Tax44
Exogenous	Treatment 3	Baseline_3	Baseline_3	Tax36	Tax36	Tax36	Tax36
Exogenous	Treatment 4	Baseline_4	Baseline_4	Tax44	Tax44	Comm.	Comm.
	Feed-back	NO	NO	YES	NO	YES	NO
	Vote	NO	NO	YES	YES	YES	YES
Endogenous	Treatment 5	Baseline_5	Baseline_5	Tax44	Tax44	Comm.	Comm.

Table 2: Contributions, Sequence 2

	Total	**Low-MC_A (K)**	**High-MC_A (L)**
Panel A: Average contributions			
Baseline	2.78	2.85	2.71
Exogenous tax44	4.81	4.53	5.09
Endogenous tax44	4.69	4.32	5.06
Panel B: Frequency of perfect cooperation			
Baseline	0.03	0.03	0.03
Exogenous tax44	0.06	0.06	0.06
Endogenous tax44	0.06	0.03	0.06
Panel C: Frequency of contributions greater than the Nash equilibrium			
Baseline	0.26	0.21	0.32
Exogenous tax44	0.21	0.24	0.47
Endogenous tax44	0.32	0.18	0.38

Table 3: Contributions, Sequence 3

	Total	**Low-MC_A (K)**	**High-MC_A (L)**
Panel A: Average contributions			
Baseline	3.63	4.00	3.26
Exogenous communication	5.06	5.94	4.18
Endogenous communication	3.93	4.24	3.62
Panel B: Frequency of free riding			
Baseline	0.25	0.18	0.32
Exogenous communication	0.34	0.21	0.47
Endogenous communication	0.44	0.35	0.53
Panel C: Frequency of perfect cooperation			
Baseline	0.09	0.09	0.09
Exogenous communication	0.35	0.44	0.26
Endogenous communication	0.26	0.26	0.26

Appendix

Appendix A: Emissions reductions, per token invested in mitigation (public account)

Tokens	Player-type	
	Low MC of abatement	High MC of abatement
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

Note: units of emissions reduced