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Public disclosure for pollution abatement

African decision-makers in a PROPER public good experiment

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Abstract: A linear public good experiment has been employed to investigate strategic behaviour in pollution abatement among African climate decision-makers. The experiment consisted of three groups of which Group 1 did not receive any treatments, and Groups 2 and 3 received one and two treatments, respectively. We found that the untreated group (baseline) polluted more than the two treated groups, while there was no statistically significant difference between the pollution abatement of the two treated groups. The results suggest that public disclosure potentially drives pollution abatement and that its eventual withdrawal does not obliterate abatement behavior. We also find that pollution levels differ significantly between males and females. Furthermore, we learned that individuals who thought it was unfair for Africa to reduce emissions polluted more.

Keywords: public good experiment, pollution control, public disclosure, Africa
JEL classification: C91, C92, Q53, Q54

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1 Introduction

Many African countries have lax environmental policies and remain safe havens for dirty industries (Abdulai and Ramcke 2009; Antweiler et al. 2001; Dasgupta et al. 1995). One of the critical reasons attributed to this is the lack of resources and the capacity to monitor firms and embark on costly and complex judicial processes if firms engage in violation. Thus, traditional instruments (e.g., taxes on emission and emission standards) are found to be ineffective in developing countries.

An alternative instrument, which is feasible and found to be cost-effective, is the Program for Pollution Control Evaluation and Rating (PROPER) scheme (see e.g. Afsah et al. 2013 for detailed discussions about the scheme). For instance, a study in Indonesia has found that the scheme is cost-saving as performance rating and public disclosure of information about firms' compliance has led to significant reduction in the costs of compliance assurance strategies. A reductions in the costs of compliance assurance strategies (Garcia et al. 2007, 2009). In Ghana, like Indonesia, the scheme works outside the formal court system and, instead, capitalizes on reputational incentives. Moreover, studies have shown that the power of ignominy could outweigh the gain from violation, and a significant number of firms improved their ratings within short periods of time when the scheme was introduced in Indonesia and Ghana. A pilot scheme was also introduced in Jiangsu Province, China, from 2005 to 2007, and the results were positive (Zhang 2010).

Notwithstanding the positive results registered, the scheme has some shortcomings. It has been found that only firms with bad ratings actively engage in improving them. With the limited sample of countries and industries so far engaged in the scheme, it is unclear whether or not such results are robust. Given that the results from laboratory experiments provide strong indications of actual behaviours, our study seeks to enrich the literature on public disclosure by engaging practitioners as subjects in a linear public good experiment in a laboratory.

The original theoretical predictions of a linear public good game are complete free-rider behaviour, since self-interest is expected to dominate all other considerations (see e.g., Bohm 1972; Isaac et al. 1994). Positive contributions are therefore regarded as anomalies rather than the rule. Over time, it became clear that contributions are rather motivated by intrinsic factors (i.e. altruism, which is related to, for instance, greed and pro-social behaviour), extrinsic or monetary, and self-image considerations (Benabou and Tirole 2006). Thus, for example, an individual who makes a positive contribution to a public good could simply be serving their self-image, especially if individual contributions are publicly disclosed, or be fulfilling a contribution norm (i.e. intrinsic motivation), which comes with guilt feelings if they deviate from such a 'contribution norm' (see e.g., Akpalu and Johansson-Stenman 2010 and Bowles and Gintis 2004). Consequently, since the weights on the three considerations could differ considerably across individuals and across cultures, both free-riding behaviour and conditional co-operation typify linear public good experiments in the laboratory and in the field (Fischbacher et al. 2001; Gächter et al. 2010; Herrmann et al. 2008; Marwell and Ames 1979).

Fischbacher et al. (2001) initiated the design of public good experiments in a manner that allows for the categorization of subjects according to their contributions: i.e. free-riders, conditional co-operators, and hump-shape contributors. The design has been applied to several cultures especially in the West (USA, Switzerland, Russia, Japan, Austria, and Denmark), as well as in Colombia and Vietnam, but the results are mixed and yield little benefit transfers (Fischbacher et al. 2001; Fischbacher and Gächter 2010; Herrmann and Thöni 2009; Kocher et al. 2008; Martinsson et al. 2013; Thöni et al. 2009).

Nevertheless, studies have found that incentives and social cohesion influence contributions in public good experiments (see e.g., Akpalu and Martinsson 2012; Bowles and Gintis 2004; Fehr and Gächter 2000; Nikiforakis and Normann 2008). This is true even if it entails verbal communication among members of a group, which could alter the weights assigned to self-image and intrinsic motivation, or allowing subjects to punish other members of the group at a monetary cost to the punisher (see e.g., Fehr and Gächter 2000 and Fehr et al. 2002). In this study, we have introduced a treatment that entails publicly disclosing the levels of pollution of all members of a group by placing a colour-coded card in front of each subject at the end of each treatment round. The colours mimic those of the PROPER scheme, which originated from Indonesia (Afsah et al. 2013). Two groups were given the public disclosure treatment for a number of rounds after which the public disclosure withdrawal treatment was given to one group in order to investigate whether or not the public disclosure treatment effect lingers on during the remaining rounds. A number of studies have introduced public disclosure in public good games but, to the best of our knowledge, this is the first time colour codes have been used to represent the levels of pollution in a linear public good experiment. Evidence exists in the public good experiment literature that repeated revelation of subjects' identity and their individual contributions could significantly increase average contribution (see e.g. Andreoni and Petrie 2004).

Indeed, some previous studies have found that publicly disclosing individual contributions increases future contribution to the provision of public goods (e.g., Ariely et al. 2009; Martinsson et al. 2013; Rege and Telle 2004; Soetevent 2005). This can be characterized as 'conditional co-operation'. However, Noussair and Tucker (2007), employing the same design as Rege and Telle (2004), and extending their one-shot game to a multi-period game, found no effect of public disclosure of own contribution on subsequent contributions in the public good experiment. Also, Martinsson et al. (2013) did not find any significant difference in unconditional contributions between the no-disclosure and disclosure treatments. It is noteworthy that even if monetary or non-monetary punishments are found to change behaviour in such experiments, culture could also play a critical role in determining the degree of effectiveness of such punishments (Gächter et al. 2010; Martinsson et al. 2013).

The results from our experiment show that our public disclosure treatment had significant impact on pollution reduction. Furthermore, the public disclosure withdrawal treatment did not obliterate the pollution abatement habits of participants, suggesting that public disclosure has a lasting impression. Thus, for the two groups that were treated, there was no significant difference between average pollution levels in each group for the last eight rounds when the public disclosure withdrawal treatment was introduced for one of the two groups. In addition, individuals who thought it is unfair for Africa to reduce greenhouse gas emissions polluted more than their counterparts who thought otherwise. Surprisingly, we did not find evidence of conditional co-operation but rather declining pollution over time, signifying the subjects were learning to avoid shame or protect the environment. These results have far-reaching implications for pollution abatement in Africa. The continent currently emits less than 4 per cent of global CO_2 but is expected to suffer disproportionately from global warming if low carbon pathways are not pursued (Canadell et al. 2009; Patz et al. 2007).[1]

[1] It is also estimated that the continent's ecological system contributes about 20 per cent of global net primary production and 40 per cent of fire emissions, which affect atmospheric chemistry (see e.g., Andreae 1991; Laporte et al. 2007). As a result, Africa is considered a major source of inter-annual variability in global atmospheric CO_2 (Ciais et al. 2011).

2 Experimental setting

The experiment, adapted from Holt and Laury 1997, is a public good game concerning global warming. Each subject in the experiment is given eight playing cards. Of this number, four were red cards and the remainder were black cards. The numbers on the cards did not matter. A red card remaining in the hands of a subject at the end of each round of the game signifies their 'CO2 emissions'. Within each round, the experimenter collects four cards from each subject and then announces to the group the total number of red cards collected. Thus, each individual decides the combinations of red and black cards to be surrendered to the experimenter. Each red card retained by a subject in a round attracted a higher marginal private benefit than the benefit from surrendering that red card. But each subject benefits from the total number of red cards surrendered by all the subjects in a group, engendering a social dilemma. The earnings for each individual in each round (and group), which are in US$, were calculated as:

$$\pi_{ik} = 4x_{ik} + y_{ik} + \sum_{j \neq i} y_{jk} \; ; i = j = 1,2, \dots 8; k = 1,2, \dots 24;$$

where π_i denotes the earnings of individual i, x_i denotes the number of red cards retained by i, y_i denotes the number of red cards surrendered by i, and y_j denotes the number of red cards surrendered by individual j, and k denotes the round being played. The experimenter pays out US$4 and US$1 for retained and surrendered red cards respectively.

In the experiment, there are eight subjects in a group, implying that if each subject surrenders all the red cards in a round, each subject earns US$32 in that round. On the other hand, if each subject keeps all the four red cards, the average earning per round will be US$16, which is lower. However, a subject could potentially earn a maximum of US$44 in a given round if everyone else surrendered their red cards in that round, and the individual kept their four red cards. In the worst-case scenario, a subject who gives out all the four red cards could earn US$4 in that round if their counterparts kept all their red cards. A complete description of the game is presented in the Appendix.

The subjects in the experiment were individuals who are involved in climate research and policy-making within Africa. They were recruited by the Center for Environmental Economics and Policy in Africa (CEEPA) to take part in a non-degree training workshop on environmental economics in Pretoria, South Africa. The 29 participants came from 12 African countries (Cameroon, Kenya, Malawi, Mauritius, Nigeria, South Africa, Sudan, Tanzania, Tunisia, Uganda, Zambia, and Zimbabwe). The intensive training workshop lasted for a week. The participants were taught a number of topics, including economics of pollution abatement, prior to the experiment.[2] Twenty-four participants were randomly selected and assigned to three groups of eight subjects each. Each group sat in a different conference room and communication was not permitted within and across groups.

Group 1 is the baseline group, in which the participants played the game without any treatment for 24 predetermined rounds. Groups 2 and 3 received treatments beginning round 9. The treatment received by Group 2 is as follows: each member of the group was assigned a colour-coded card at the end of each round according to their level of pollution (i.e. the number of red cards retained). The card was placed in front of their desk and was visible to all other members of the group. A black, red, blue, green, and gold card indicates the subject kept four, three, two,

[2] Since all the subjects took the course, it is expected that the relative abatement levels will not be significantly impacted.

one, and no red cards, respectively. The objective of this treatment is to publicly disclose each subject's pollution level for each round to the other members of the group. The treatment lasted from round 9 to 24. In practice, the PROPER scheme may impact the profitability of firms who receive bad ratings. In our experimental setting, the treatment is expected to trigger shame, which imposes a psychic cost on the perpetrator. According to Andreoni and Petrie (2004), an individual may feel shame if they engage in an inappropriate action and know that others know of their actions. Thus, an individual may feel shame if they pollute more than others and their action is revealed to the rest of the group. Group 3 received the same treatment as Group 2 from round 9 to 16. Beginning round 17 the public disclosure withdrawal treatment was administered. Thus, Groups 1 and 3 played the same game from rounds 17 through 24. The objective is to determine whether or not withdrawing the PROPER public disclosure results in a change in pollution abatement behaviour. At the end of the experiment the total amount earned was converted to grade points in the course according to an exchange rate of US$10 = 1 grade point. This information was provided to the subjects upfront.

Prior to beginning the experiment, each subject was asked to complete a short questionnaire, which included questions on demographic characteristics, whether or not the subject had taken a course in economics at college level, etc. A sample of the instrument is in Appendix. Each round of the experiment lasted approximately five minutes, and the entire experiment lasted two hours. Table 1 gives a summary of the three groups and the treatments received.

Table 1: Summary of groups and treatments in pollution experiment

Group 1	Group 2 – Treatment 1	Group 3 – Treatment 2
Rounds 1-8		
Baseline (No Treatment, Normal Public Good Game)	Baseline (No Treatment, Normal Public Good Game)	Baseline (No Treatment, Normal Public Good Game)
Rounds 9-16		
Baseline (No Treatment, Normal Public Good Game)	Treatment 1 (Public disclosure using colour codes to signify pollution levels)	Treatment 1 (Public disclosure using colour codes to signify pollution levels)
Rounds 17-24		
Baseline (No Treatment, Normal Public Good Game)	Treatment 1 (Public disclosure using colour codes to signify pollution levels)	Treatment 2 (Public disclosure withdrawal; Normal Public Good Game)

Source: Authors' illustration.

3 Results and discussions

Table 2 presents the descriptive statistics of the subjects in the experiment. Of the total number of participants, 38 per cent were female. The mean age was 40 years, with a relatively low standard deviation of 10, which implies individual ages were clustered around the mean. Furthermore, approximately 70 per cent of the respondents had taken at least one course in economics at college level, and only a third of them thought it fair for Africa to pursue low carbon development pathways. The overall average years of working experience was 13.5 years, which is fairly high, with a standard deviation of 8.1.

Table 2: Descriptive statistics of variables across groups in a pollution game in Africa

Variable	Group 1		Group 2		Group 3		All groups	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age (in years)	43	10.54	43	5.249	35	6.837	40	9.695
Studied economics (1/0)	0.75	0.434	0.571	0.496	0.625	0.485	0.679	0.467
Work experience (in years)	16.125	9.596	15.857	5.735	10.375	5.736	13.535	8.132
Female (1/0)	0.625	0.485	0.125	0.332	0.375	0.485	0.379	0.486
Fair for Africa to reduce CO_2 emissions (1/0)	0.286	0.453	0.286	0.453	0.25	0.434	0.32	0.467
Own pollution	1.766	1.327	2.198	1.275	2.484	1.139	2.149	1.282

Source: Authors' own experimental data and survey data.

As discussed earlier, the experiment consisted of 24 rounds. Since there were only eight subjects per group, intergroup comparisons of levels of pollution prior to and post-treatments must be made with caution. We have made attempts at controlling for group-specific effects when doing intergroup comparisons. Table A1 in the Appendix presents the distribution of pollution across the groups and rounds, and Figures 1A through 1C compare the average levels of pollution (i.e. number of cards retained) within rounds 1-8 and 17-24 for each subject in the various groups. The results from the baseline group (which received no treatment), designated Figure 1A, shows that all but one subject (i.e. 88 per cent) in the group retained more cards, on average, in the last eight rounds than in the first eight rounds. For Group 2, which received the public disclosure treatment from round 9 to 24, the data indicate that only two subjects (25 per cent) kept more cards, on average, in the last eight rounds than in the first eight rounds (see Figure 1B). Group 3 received the public disclosure treatment from round 9 and the public disclosure withdrawal treatment after round 16. The results presented in Figure 1C show that three subjects (38 per cent) retained more red cards (i.e. polluted more) in the last eight rounds compared to the first eight rounds. These results suggest that public disclosure could lower pollution levels of firms but it is unclear whether or not withdrawing public disclosure would significantly reverse/negate pollution abatement.

Results of a Mann-Whitney test indicate that the average pollution levels of the untreated group (Group 1) and Group 2 or Group 3 are significantly different at the 1 per cent level ($p<0.0007$ and $p<0.0014$, respectively). However, the evidence is not strong to show that average pollution levels for the two treated groups are statistically different ($p<0.071$), implying that public disclosure has a lingering effect.[3]

[3] Figure A1 in the Appendix presents the frequency distribution of the marks/scores obtained during the experiment. The minimum mean score is 56.7, with a standard deviation of 9.48. Note that the social optimum score is 76.8 points, which is higher than the maximum score of 72.9.

Figure 1A: Group 1. Comparing average number of cards retained by students in the baseline group. Rounds 1-8 vs 17-24.

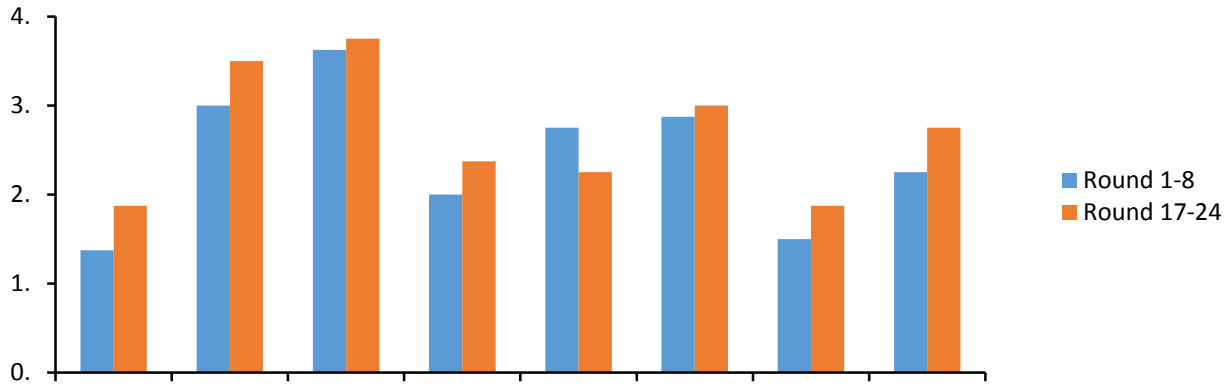


Figure 1B: Group 2. Comparing average number of cards retained by subjects in the treated group. Rounds 1-8 vs 17-24. Treatment 1 was from round 9-24.

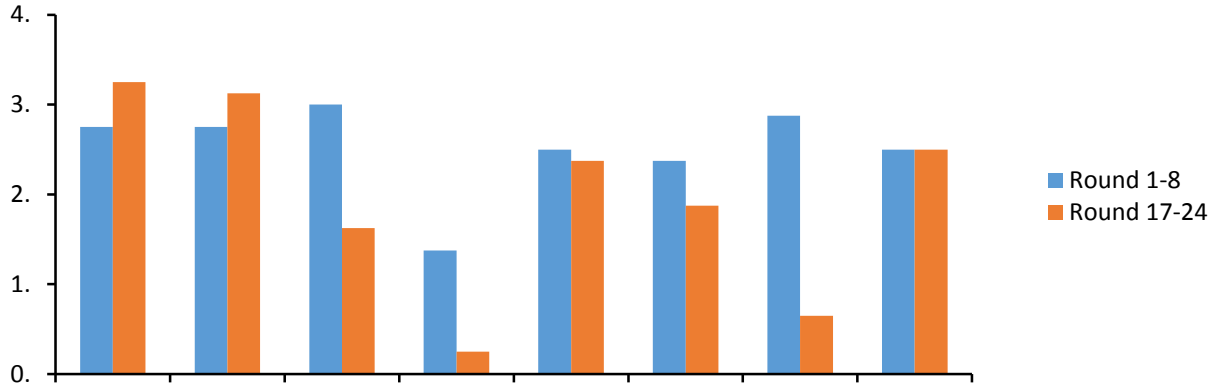
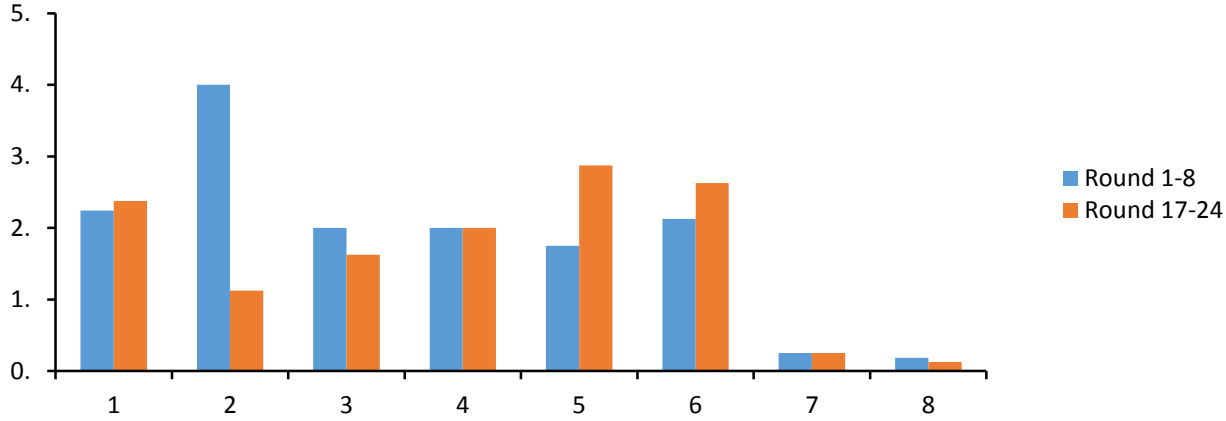


Figure 1C: Group 3. Comparing average number of cards retained by subjects in the treated group. Rounds 1-8 vs 17-24. Treatment 1 was from round 9-16; and Treatment 2 from round 17-24.



Source: Authors' illustration based on the experimental data.

The preliminary analysis above, Figures 1A-1C, suggests that public disclosure of economic agents' pollution levels can potentially reduce overall pollution, and that its subsequent withdrawal does not seem to obliterate abatement behaviour. In the ensuing sections, we

empirically evaluate the impact of public disclosure on pollution abatement, and also assess the covariates of pollution abatement using regression analysis.

Two equations were estimated: an Ordinary Least Squares (OLS) regression of the determinants of levels of pollution (i.e. the number of red cards retained); and a Logit model to investigate the determinants of the probability of retaining more red cards within the last eight rounds than the first eight rounds. We estimate these two equations separately arguing that the decision on the number of red cards retained is independent of the probability of retaining more red cards within the last eight rounds than the first eight rounds. We surmise that this assumption will hold given that the probability of retaining more red cards will be a function of the treatment. The explanatory variables considered in the OLS and Logit regressions include own and group average pollution in the previous round, irrespective of gender, whether or not the subject studied economics in college, whether or not the subject thinks it is fair for Africa to pursue low carbon pathways, and group-specific fixed effects.

The results of the OLS estimation are reported in Table 3. The coefficient of determination indicates that about 38 per cent of the variability in the levels of pollution is explained by the explanatory variables, and the F-statistic indicates an overall goodness of fit of the model. Regarding the explanatory variables, the results indicate that conditional on the same treatment and demographics, an individual's current level of pollution is conditional on their immediate past pollution level. The corresponding marginal effect and elasticity coefficient is 0.14, implying that the pollution level has generally been increasing over time, all else being equal. Second, the coefficient of time trend (i.e. rounds) is statistically significant at the 1 per cent level and has a negative sign, meaning that, holding other factors constant, the number of red cards retained by the subjects in the experiment declined over time. This is an indication of learning taking place over time. Next, the coefficient of age is positive and significant at the 1 per cent level. Thus, the older subjects polluted more than their younger counterparts. This is consistent with the findings in the literature that, compared to older adults, younger adults are more likely to believe that climate change is happening, and that it is anthropogenic (see e.g. Maibach et al. 2013). In addition, females polluted more than males. This result is quite unexpected since studies have found that climate change often burdens women more than men, marginalization of women makes them more vulnerable to climate change impacts than men, and women are generally more concerned about climate change than men (Habtezion 2014; Korkala et al. 2014; McCright 2010; Olsson et al. 2014).[4]

Furthermore, the subjects who were of the opinion that it is unfair for Africa to reduce emissions polluted more (kept 2.7 more red cards) than their counterparts who thought it was fair.[5] This finding is consistent with expectation and underscores the need for investment in educating people about the need for Africa to pursue low carbon pathways to avoid greater adaptation and mitigation costs in the future. Perhaps the starting point could be a serious engagement on the question of climate justice by the international community to ensure that Africans buy into climate change mitigation efforts, in particular, the principle of *common but differentiated responsibilities*. Initiatives such as the Green Climate Fund, REDD+, etc., are important in this regard as they tend to lower the adjustment costs for African countries as they transition to a low carbon development path.

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[4] This may however be an indication that a threshold exists on survival that needs to be achieved before concern for climate change impact kicks in.

[5] This perception of unfairness is underpinned by the fact that Africa contributes marginally to global CO_2 emissions (about 4 per cent), and has not been a major contributor to historical atmospheric greenhouse gas concentrations.

Finally, and perhaps most importantly, the coefficient of a variable depicting an interaction of Group 1 (the baseline group) and the last eight rounds was statistically significant at the 1 per cent level and has a positive sign. This implies that, for the last eight rounds, individuals in the untreated group (baseline group) retained more red cards (approximately one more) than their counterparts in the other two groups, when group-specific effects are controlled for. Perhaps quite surprising is the finding that there was no significant difference between the number of red cards retained, on the average, between Group 2, which had public disclosure within the last eight rounds and their counterparts in Group 3, for whom public disclosure was withdrawn after the 16th round. This finding nevertheless appears to be consistent with Figures 1A through 1C, and the results of the Mann-Whitney test. Previous public good experiments found significant decline in individual contributions when punishments were withdrawn (see e.g. Masclet and Villeval 2008). Furthermore, the subjects were not conditionally co-operating. Thus, the past average behaviour of the group did not influence the individual's future levels of pollution.

Table 3: Ordinary least square regression of determinants of pollution in a public good game in Africa

Variables	Coefficient	Elasticity
Own pollution in previous rounds (Y_{t-1})	0.144 (0.054)***	0.142
Round (1-24)	-0.040 (0.011)***	-0.244
Group average in previous round (AVG_{t-1})	0.080 (0.150)	
Studied economics in college (1/0)	-3.345 (0.669)**	-2.569
Group2*Rounds_C (i.e. 17-24 rounds)	0.150 (0.224)	
Group1*Rounds_C (i.e. 17-24 rounds)	0.714 (0.199)***	0.042
Fair (1/0)	-2.695 (0.425)***	-2.185
Age (in years)	0.340 (0.077)***	6.477
Female (1/0)	0.831 (0.224)***	0.620
Group 1 (reference group)		
Group 2 (1/0)	-2.275 (0.450)***	-0.340
Group 3 (1/0)	-0.587 (0.221)***	-0.088
Constant	-7.503 (2.198)***	
Observations	506	
R^2	0.38	
F-Stat	19.25***	

Note: The robust standard errors are in parentheses. **, *** significant at 5 and 1 per cent, respectively.

Source: Authors' estimates from survey and experimental data.

As noted earlier, the second regression equation (i.e. the Logit model reported in Table 4), investigates the determinants of the probability of a subject retaining more red cards in the last eight rounds than in the first eight rounds. The Wald chi-square test indicates the line is a good fit at the 5 per cent significance level and the pseudo coefficient of determination reveals that about 33 per cent of the variation in the logarithm of the odds ratio is explained by the given explanatory variables.

Table 4: Logit regression of determinants of increased pollution in a public good game in Africa

Variables	Coefficient	Marginal effect
Studied economics in college (1/0)	2.392 (1.34)*	0.361
Fair for Africa to reduce CO_2 emissions (1/0)	-1.889 (1.119)*	-0.285
Age (in years)	-0.100 (0.072)	
Female (1/0)	-0.103 (1.193)	
Group1 (No treatment)	2.157 (1.075)**	0.325
Constant	0.486 (3.671)	
Observations	22	
Pseudo R^2	0.33	
Wald Chi^2 (5)	10.85**	

Note: The robust standard errors are in parentheses. *, ** significant at 10 and 5 per cent, respectively.

Source: Authors' estimates from survey and experimental data.

Regarding the explanatory variables with significant coefficients, individuals who studied economics at college level were more self-interested, and therefore had a higher probability (0.36 higher) of polluting more in the last eight rounds than their counterparts who did not study economics at the college level. Comparing this result to the earlier finding in Table 3, the subjects in the experiment who studied economics at college level surprisingly polluted less, but their pollution levels were higher in the last eight rounds than their first eight rounds, relative to their counterparts who did not study economics in college. Secondly, individuals who indicated that it was unfair for Africa to reduce CO_2 emissions had a 0.32 higher probability of polluting more in the last eight rounds compared to their first eight rounds. Finally, compared to Groups 2 and 3, individuals in Group 1 had a higher probability of retaining more red cards in the last eight rounds. This finding is consistent with the discussion about Figures 1A through 1C presented earlier. As a result there is a strong indication that publicly disclosing the pollution levels of individuals could potentially lead to cutting down emissions.

4 Concluding remarks

The results from a pollution game played by African climate researchers and decision-makers in a laboratory reveal that publicly disclosing an individual's pollution level to the rest of the members of a group they belong to could significantly engender pollution abatement. This indicates that such a policy instrument could be employed by African countries, especially those that are experiencing high and increasing levels of pollution due to lax environmental regulations. It must be noted that at the individual level the public disclosure may shame a recalcitrant and this could result in the psychic cost of guilt. At the level of firms, however, public disclosure could reduce a firm's reputation, market share, and subsequently its profitability, particularly given increasing consumer awareness about the environment.

Furthermore, the finding that the perceived fairness of Africa pursuing low carbon development determines whether an individual pollutes more or less has far-reaching implications. Perhaps the question of climate justice needs to be taken seriously and conclusively addressed by the international community for widespread buy-in of climate mitigation initiatives by Africans. In the absence of significant investments to achieve such buy-in and to foster climate education of the relevant policy-makers and the general public within the continent, it is likely that aggregate pollution levels within the continent may continue to rise over time.

Finally, evidently, individual characteristics are important in determining the levels of pollution and may be explored when designing and implementing climate policies. For example, the finding that age positively correlates with pollution may be due to differences in the rate of time

preference across age groups. If this is true, then younger decision-makers should be encouraged to take leadership positions in climate negotiations and policy-making in the continent. In addition, we have found that the gender of the individual could determine their level of pollution.

Our sample, though vital, is limited and therefore constrains the extent to which the results could be generalized. Nevertheless, the fact that the subjects in the experiment are selected based on their role in climate decision-making and climate research experience within the continent, suggests that these results ought to be taken seriously.

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Appendix

The pollution game

Each of you represents an industry that emits carbon dioxide (CO_2). Each of you will be given eight cards, four of these cards are **red** (hearts or diamonds), and four of these cards are **black** (clubs or spades). The number on the card does not matter. The exercise will consist of a number of rounds. When a round begins, I will come to each one of you, and you will play four of your eight cards by placing these four cards face-down on top of the stack in my hand.

Your red cards are your 'CO_2 emissions' cards. Your earnings in dollars are determined by what you do with your **red** cards. For each **red** card that you keep you will earn four dollars (US$4) for the round, and for each black card that you keep you will earn nothing. When you keep a **red** card you are choosing to continue to emit CO_2. The net benefit (benefit-cost) your industry receives is four dollars (US$4). When you give up a **red** card you are choosing to cut back on your emissions of greenhouse gases. The net direct benefit your industry receives is zero dollars (US$0) on that card.

Red cards that are placed on the stack increase everyone's earnings. I will count up the total number of 'emission reductions' (**red**) cards in the stack, and everyone will earn an equivalent of the number of **red** cards times one dollar (US$1). This represents the gains to society from the avoidance of global warming (e.g., avoidance of sea level rise, skin cancer, etc.). **Black** cards placed on the stack have no effect on the count. When the cards are counted, I will not reveal who made which decisions. I will return your own cards to you at the end of the round by coming to each one of you in reverse order and giving you the top four cards, face-down, off the stack in my hand. Please do not disclose your cards to your peers. You are also not allowed to communicate with anyone in your group during the entire exercise.

To summarize, your earnings for the round will be calculated as:

Earnings = [US$4 x (number of **red** cards you keep)] + [US$1 x (number of **red** cards I collect)]

Use the earnings record sheet provided to you to record your decisions, your earnings, and your cumulative earnings. At the end of the game, you will be awarded one point for every US$10 you made in the game. These points will constitute your grade for the lectures on Economics of Pollution Management that you have just taken.

Record sheet

Rounds	(A) No. of red cards you keep	(B) value of red cards	(C = A x B) points for red cards kept	(D) total no. of red cards not kept	(E) value of red cards not kept	(F = D x E) earnings for red cards not kept	(G = C + F) total earnings this round
1		US$4			US$1		
2							
3							
.							
.							
.							
24							

Treatments

Treatment 1

Beginning from the next round you will receive a colour-coded card that will indicate your level of pollution (i.e. the number of red cards you decided to keep) in each round. The colour-coded card, which will be placed in front of you, will be visible to all the other members of your group. The objective of this policy is to publicly disclose your pollution level for each round. The following are the colour codes and the corresponding number of red cards you decide to keep:

BLACK: You kept all your FOUR red cards

RED: You kept THREE red cards

BLUE: You kept TWO red cards

GREEN: You kept ONE red card

GOLD: You kept NO red card.

Treatment 2

Beginning from the next round, I will no longer reveal your pollution level to your peers. Thus, no colour-coded cards will be used and no firm in your group will know your specific level of pollution.

Sample questionnaire

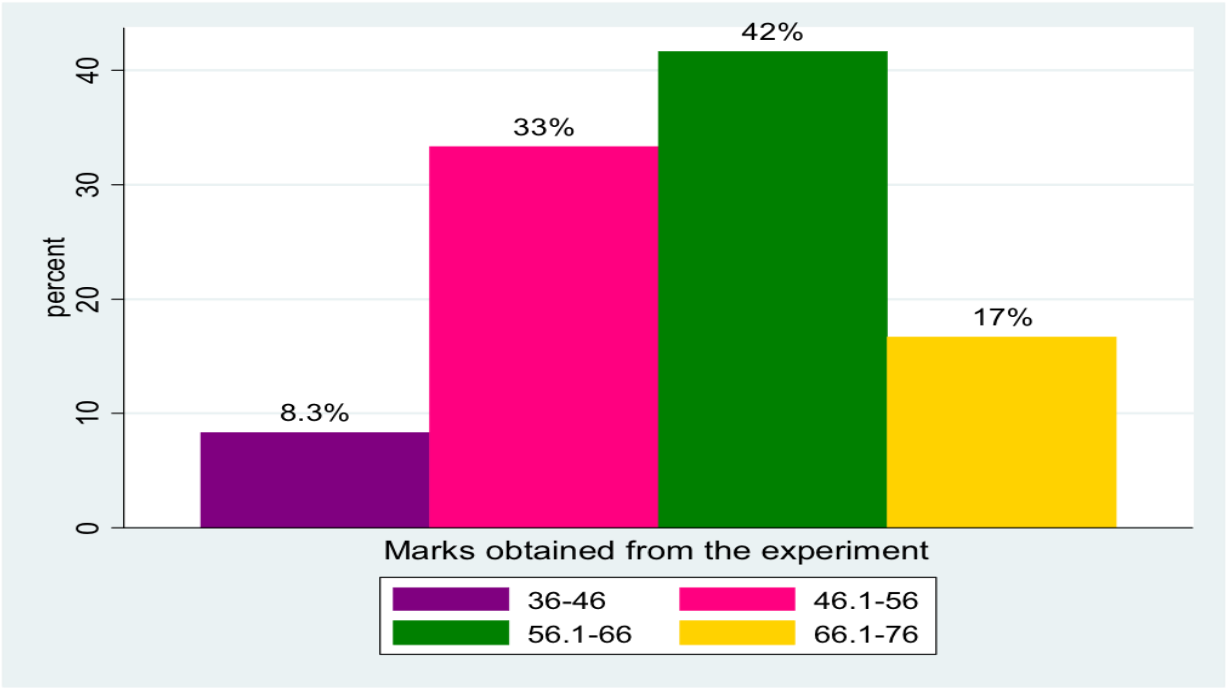
(1) Your name……..
(2) Country of origin…….
(3) Institutional affiliation……..
(4) Total number of years of work experience……
(5) Total numbers of years of working in a policy-making or decision-making capacity……
(6) Have you ever been involved in any climate negotiations? Yes or No.
(7) Field of study in your last formal education…….
(8) Highest degree received……
(9) Have you ever taken any university/college-level course in economics?.....
(10) Do you think it is fair for Africa to pursue a low carbon development pathway? Yes or No.
(11) What is your gender? Male or Female.
(12) What is your age?.....

Table A1: Distribution of pollution across groups and rounds in a public good game in Africa

Group	Rounds 1-8 (A)		Rounds 9-16 (B)		Rounds 17-24 (C)	
	Mean	SD	Mean	SD	Mean	SD
1	2.031	1.297	1.641	1.350	1.625	1.315
2	2.515	1.272	2.125	1.076	1.953	1.407
3	2.422	1.232	2.359	1.160	2.672	1.009

Source: Authors' estimates from survey and experimental data.

Figure A1: Frequency distribution of scores (marks) obtained in the experiment



Source: Authors' own illustration.