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RESEARCH ARTICLE

Public disclosure for carbon abatement: African decision-makers in a PROPER public good experiment

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A linear public good experiment adopted from Holt and Laury [1997. Classroom games: Voluntary provision of a public good. Journal of Economic Perspectives, 11(4), 209–215.] has been employed to investigate strategic behaviour in pollution abatement among African climate decision-makers. The experiment consisted of three groups, of which groups 2 and 3 received one and two treatments, respectively. The first treatment entailed publicly disclosing the pollution of each member of a group by placing a corresponding colour-coded card in front of each subject, while the second involved the withdrawal of the public disclosure. Group 2 received the first treatment; Group 3 received both the first and second treatments in succession. We found that the untreated group (baseline) polluted more than the two treated groups, and there was no statistically significant difference between the pollution abatement of the two treated groups. These results suggest that public disclosure potentially drives pollution abatement and that its eventual withdrawal does not obliterate abatement behaviour. We did not observe conditional cooperation but average pollution declined over time. Furthermore, individuals who thought it was unfair for Africa to reduce emissions polluted more. We also found that pollution levels differ significantly between males and females.

Keywords: public good experiment; carbon abatement; public disclosure; Africa

1. Introduction

Sub-Saharan African countries typically have lax environmental regulations and remain safe havens for dirty industries (Abdulai & Ramcke, 2009; Antweiler, Copeland, & Taylor, 2001; Dasgupta, Mody, Roy, & Wheeler, 1995).[1] There may be many reasons for this. For example, a nation may be reluctant to enforce environmental regulation if that regulation could negatively affect the country's comparative advantage in producing high-abatement-cost products (see Baumol & Oates, 1988). In addition, most countries, especially in the developing world, lack the resources and the capacity to monitor firms, and to embark on costly and complex judicial processes if firms violate environmental regulations (Boocock, 2002; Khanna, 2001). In such countries, traditional instruments such as taxes on emission and emission standards are ineffective. A study by Dam and Scholtens (2008), for example, found that multinational firms with low environmental standards gravitate towards poor countries (mostly in Africa) that have low environmental standards and high level of corruption.

Compared to other continents in the world, Africa emits low amounts of Green House Gases (GHGs) (African Development Report [ADR], 2012; Akpalu, Arndt, & Matshe, 2015; Vorster, Winkler, & Jooste, 2011).[2] Although the continent's total carbon dioxide (CO_2) emissions have increased by about 35% over the last two decades according to recent estimates, the continent's emission per capita is about 13 times less than that of North America (ADR, 2012; IEA, 2012). A study on decomposition analysis of CO_2 across regions in the world found that Africa is the only region that has been able to register economic growth and consistent reductions in energy and carbon intensities simultaneously (Mundaca, Markandya, & Nørgaard, 2013).[3] Nevertheless, Africa remains the most vulnerable to climate change impacts. The continent is least able to cope with climate change and a large number of the poor and the marginalized engage in economic activities that are concentrated in climate sensitive sectors (Houghton et al., 2001; Vorster et al., 2011). It is noteworthy that no country in Africa is currently obliged to meet any specific emission reduction target, due to

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relatively low levels of GHG emissions. The challenge is how to ensure that the continent continues to register high economic growth while pursuing low-carbon development pathways in order to avert potentially damaging future climate impacts (ADR, 2012).[4] Indeed, for carbon abatement strategies to be effective, African nations must jointly address economic development and social welfare or poverty impacts (Garibaldi et al., 2014; Vorster et al., 2011).

Non-mandatory information disclosure strategies are feasible and cost-effective instruments for regulating emissions (Khanna, 2001; Maxwell, Lyon, & Hackett, 2000; Segerson & Miceli, 1998). Pollution abatement is a public good, and in the absence of credible sanctions, firms have little to no incentives to cut down emissions (Jorgensen & Syme, 2000; Smulders & Gradus, 1996). By publicly providing information on firms' compliance with environmental regulations, information disclosure strategies engender market forces that create demand for environmental self-regulation by firms (Khanna, 2001). Thus, firms undertake voluntary regulations based on self-interest. The extent of compliance with environmental regulations may impact public opinion and firms' relationship with customers, and these in turn influence firms' market share or prices of products (Khanna, 2001; Storey, Boyd, & Dowd, 1999). There are three types of these voluntary initiatives: public voluntary programmes, which are crafted by environmental regulators; bilateral negotiations between regulators and polluting firms on abatement targets and plans; and firms' unilateral demonstration of environmental stewardship (Carraro & Leveque, 2013; Davies & Mazurek, 1996; Khanna, 2001; Storey et al., 1999).

A typical example of a public voluntary programme, and one that has been implemented in a few developing countries, is the Program for Pollution Control Evaluation and Rating (PROPER) scheme (see e.g. Afsah, Blackman, Garcia, & Sterner 2013 for detailed discussions about the scheme). A study of the scheme's effects in Indonesia found that the use of performance rating and the public disclosure of information about firms' compliance have led to a significant reduction in the costs of compliance assurance strategies (Garcia, Afsah, & Sterner, 2009; Garcia, Sterner, & Afsah, 2007). In Ghana, like Indonesia, the scheme works outside the formal court system and rather 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 (Afsah, et al., 2013; Garcia et al., 2007; Garcia et al., 2009). 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, the scheme has some shortcomings. It has been found that only firms with bad ratings actively engage in improving them. Also, with the limited sample of countries and industries so far engaged in the scheme, it is unclear whether such results are generalizable. Due to these shortcomings, and given that the results from laboratory experiments provide strong indications of actual behaviours, our study seeks to enrich the literature on public voluntary disclosure programmes by engaging practitioners as subjects in a laboratory-based linear public good experiment.

The original theoretical predictions of a linear public good game were that of complete free-rider behaviour, since self-interest was expected to dominate all other considerations (see e.g. Bohm, 1972; Isaac, Walker & Williams, 1994). Positive contributions were therefore regarded as anomalies rather than the rule. Over time, it became clear that contributions are rather motivated by intrinsic (e.g. altruistic, which is related to, for example, greed and pro-social behaviour), extrinsic/monetary, and self-image considerations (Benabou & Tirole, 2006). Thus, for example, an individual who makes a positive contribution to a public good could simply be serving his/her self-image, especially if individual contributions are publicly disclosed; or the individual may be fulfilling a contribution norm, which is intrinsically motivating as deviation from the contribution norm engenders guilt feeling (see e.g. Akpalu & Johansson-Stenman, 2010; Bowles & 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, Gächter, & Fehr, 2001; Gächter, Herrmann, & Thöni, 2010; Herrmann, Thöni, & Gächter, 2008; Marwell & Ames, 1979).

Fischbacher et al. (2001) initiated the design of public good experiments in a manner that allows for the categorization of subjects as free-riders, conditional co-operators, and hump-shape contributors, according to their contributions. The design has been applied to several cultures in the West (USA, Switzerland, Russia, Austria, and Denmark), as well as in Japan, Colombia, and Vietnam, but the results have been mixed and yielded little benefit transfers (Fischbacher & Gächter, 2010; Fischbacher et al., 2001; Herrmann & Thöni, 2009; Kocher, Cherry, Kroll, Netzer, & Sutter, 2008; Martinsson, Pham-Khanh, & Villegas-Palacio, 2013; Thöni, Tyran, & Wengström, 2009).

Nevertheless, studies have found that incentives and social cohesion influence contributions in public good experiments (see Akpalu & Martinsson, 2012; Bowles & Gintis 2004; Fehr & Gächter, 2000; Nikiforakis & 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 allows subjects to punish other members of the group at a monetary cost to the punisher (see Fehr & Gächter,

2000 and Fehr, Fischbacher, & Gächter, 2002). In this study, we have introduced a treatment which 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 in Indonesia (Afsah et al., 2013). Two groups were given the public disclosure treatment for a number of rounds, then the public disclosure withdrawal treatment was given to one of the two groups in order to investigate whether the public disclosure treatment effect lingered 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 Andreoni & Petrie, 2004).

Indeed, some previous studies have found that publicly disclosing individual contributions increases future contribution to the provision of public goods (Ariely, Bracha, & Meier, 2009; Martinsson et al., 2013; Rege & Telle, 2004; Soetevent, 2005). This can be characterized as "conditional cooperation". 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 that public disclosure of own contribution had no effect on subsequent contributions in the public good experiment. Also, Martisson 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 remainder of the paper is organized as follows: the next section (Section 2) presents the experimental setting, and this is followed by discussion of the results in Section 3. The final section, that is, Section 4, concludes the paper.

2. Experiment setting

The experiment, which was adapted from Holt and Laury (1997), was a public good game concerning global warming. Each subject in the experiment was given eight playing cards. Of this number, four are red cards and the remainder are black cards. The numbers on the cards do not matter. A red card remaining in the hands of a subject at the end of each round of the game signified his/her "CO_2 emissions". Within each round, the experimenter collected four cards from each subject and then announced to the group the total number of red cards collected. Thus, each individual decided the combinations of red and black cards to be surrendered to the experimenter. Each red card retained by a subject in a round attracts a higher marginal private benefit than the benefit from surrendering that red card. But each subject would also benefit from the total number of red cards surrendered by all the subjects in a group, engendering a social dilemma. The experimenter pays out \$4 and \$1 for retained and surrendered red cards, respectively. The earnings for each individual in each round (and group), which is in US dollars, is calculated as:[5]

$$\pi_{ik} = 4R_{ik} + B_{ik} + \sum_{j \neq i} B_{jk}; \;\; i = j = 1, 2, \ldots, 8;$$

$$k = 1, 2, \ldots, 24,$$

where π_i denotes the earnings of individual i; R_i denotes the number of red cards retained by i; B_i denotes the number of red cards surrendered by i and B_j denotes the number of red cards surrendered by individual j and k denotes the round being played.

In the experiment, there were eight subjects in a group, implying that if each subject surrendered all the red cards in a round, he/she would earn US\$32 in that round. On the other hand, if each subject kept all four red cards, the average earning per round would have been US\$16, which is lower. A subject could have potentially earned a maximum of US\$44 in a given round if everyone else surrendered their red cards in that round, while he/she kept his/her four red cards. In the worst case scenario, a subject who gave out all four red cards could have earned US\$4 in that round if his/her counterparts kept all their red cards. A complete description of the game is presented in Appendix 1.

The experiment used two treatments. The first treatment (public disclosure) was as follows: each member of the group was assigned a colour-coded card at the end of each round according to his/her level of pollution (i.e. the number of red cards retained). The card was placed in front of his/her desk and was visible to all other members of the group. A black, red, blue, green, and gold card indicated that the subject kept four, three, two, one, and no red cards, respectively. The objective of this treatment was to publicly disclose each subject's pollution level to the other members of the group for each round. In practice, the PROPER scheme may impact the profitability of firms who receive bad ratings. In our experimental setting, the first treatment was expected to trigger shame, which imposed a psychic cost on the perpetrator. According to Andreoni and Petrie (2004), an individual may feel shame if he/she engages in an inappropriate action and knows that others know of his/her actions. Thus, an individual may feel shame if he/she pollutes more than others and his/her action is revealed to the rest of the group.

The second treatment (public disclosure withdrawal) was as follows: each member of the group was assigned a colour-coded card at the end of each round according to her level of pollution (i.e. the number of red cards retained). In contrast to the first treatment, no card was placed in front of her desk to reveal each subject's pollution level for each round to the other members of the group. The objective of this treatment was to withdraw public disclosure of each subject's pollution level for each round to the other members of the group, which had become a norm in the previous eight rounds.

Group 1 is the baseline group, for which the participants played the game without any treatment for 24 predetermined rounds. Group 2 received the first treatment (public disclosure) from round 9 to 24. Group 3 received the first treatment (public disclosure) from round 9 to 16 and the second treatment (public disclosure withdrawal) beginning round 17. Thus the three groups were all not treated in the first eight rounds, while Groups 2 and 3 received the same treatment (public disclosure) from round 9 to 16. The objective of the experiment was to determine whether or not withdrawing the PROPER public disclosure resulted 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 the subject's demographic characteristics and whether the subject had taken a course in economics at the college level. A sample of the instrument is in Appendix 1. 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.

3. Results and discussion

The subjects in the experiment were individuals who had been 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 an environmental economic training workshop located 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 workshop lasted for a week, and the participants were taught a number of topics, including economics of pollution abatement, prior to the experiment.[6] 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 or across groups.[7]

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

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-treatment must be made with caution. We attempted to control for group-specific effects when doing intergroup comparisons. Figures 1–3 compare the average levels of pollution (i.e. the number of cards retained) within round 1–8 and 17–24 for each subject in the various groups. The results from the baseline group (which received no treatment), designated Figure 1, show that all but one subject (i.e. 88%) in the group retained more cards, on average, in the last eight rounds than 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%) kept more cards, on average, in the last eight rounds than the first eight rounds (see Figure 2). Group 3 received the public disclosure treatment from round 9 and the public disclosure withdrawal treatment

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)

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 CO2 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

after round 16. The results presented in Figure 3 show that three subjects (38%) 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 are unclear about whether withdrawing public disclosure would significantly reverse/negate pollution abatement.

Results of 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% level ($P < .0007$ and $P < .0014$, respectively). However, the evidence is not strong enough to show that average pollution levels for the two treated groups are statistically different ($P < .071$), implying that public disclosure has a lingering effect.[8]

The preliminary analysis above, Figures 1–3, suggests that public disclosure of economic agents' pollution levels can potentially reduce the overall pollution, and that its subsequent withdrawal does not seem to obliterate abatement behaviour. In the ensuing sections, we empirically evaluate the impacts 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.[9] We estimated these two equations separately, arguing that the decision on the number of red cards retained was independent of the probability of retaining more red cards within the last eight rounds than the first eight rounds. We surmised that this assumption would hold, given that the probability of retaining more red cards was a function of the treatment. The explanatory variables considered in the OLS and Logit regressions included own and group average pollution in the previous round; whether the subject studied economics in college; whether the subject in the experiment thought it was fair for Africa to pursue low-carbon pathways; subject gender; and group-specific fixed effects.

The results of the OLS estimation are reported in Table 3. The coefficient of determination indicates that about 38% of the variability in the levels of pollution is explained by the explanatory variables for the first estimation (i.e. the first two columns of the results: (1)), 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 depends on his/her 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 equal. Second, the coefficient of time trend (i.e. rounds) is statistically significant at the 1% level and has a negative sign, meaning, holding other factors constant, that 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% 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

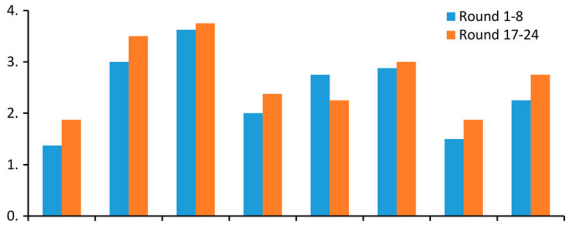

Figure 1. Group 1. Comparing average number of cards retained by subjects in the baseline group: rounds 1–8 vs. 17–24.

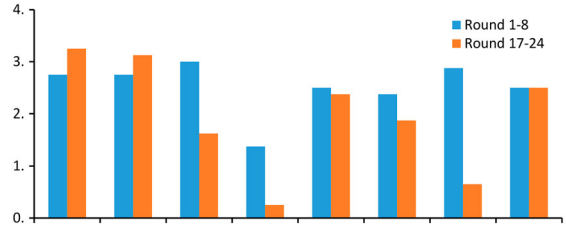

Figure 2. Group 2. Comparing average number of cards retained by subjects in the treated group: rounds 1–8 vs. 17–24. Treatment 1 was from round 9 to 24.

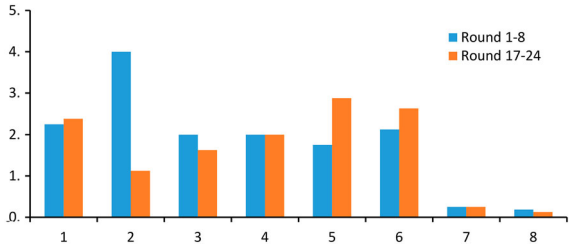

Figure 3. Group 3. Comparing average number of cards retained by subjects in the treated group: rounds 1–8 vs. 17–24. Treatment 1 was from round 9 to 16; and Treatment 2 from round 17–24.

adults are more likely to believe that climate change is happening, and that it is anthropogenic (see Maibach, Bloodheart, & Zhao, 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, that marginalization of women makes them more vulnerable to climate change impacts than men, and that women are generally more concerned about climate change than men (Korkala, Hugg, & Jaakkola, 2014; McCright, 2010; Habtezion, 2012; Olsson et al., 2014).[10]

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.[11] This finding is consistent with our expectations 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 of the question of climate justice by the international community to ensure that Africans buy into climate change mitigation efforts, and in particular, the principle of *common but differentiated responsibilities*. Initiatives such as the Green Climate Fund and REDD+ are important in this regard, as they tend to lower the adjustment costs for African countries in their transition to a low-carbon development path. However, from the results reported in the last two columns, in the last eight rounds when only Group 2 remained treated with public disclosure, those who were of the view that it is unfair for Africa to pursue low-carbon pathways kept more red cards than their counterparts who had the contrasting view. This may simply be due to spite, which is consistent in the experimental literature. Thus, individuals were ready to incur costs in order to punish free-riders in a public good game (see. Fehr & Gächter, 2000).

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% 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 were controlled for. Perhaps quite surprising is the finding that there was no significant difference between the number of red cards retained, on 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

Table 3. OLS Regression of determinants of pollution in a public good game in Africa.

	(1)		(2)	
Variables	Coefficient	Elasticity	Coefficient	Elasticity
Own pollution in previous rounds (Y_{t-1})	0.144 (0.054)***	0.142	0.144(0.054)***	0.142
Round (1–24)	−0.040 (0.011)***	−0.244	−0.035(0.011)***	−213
Group average in previous round (AVG $_{t-1}$)	0.080 (0.150)		0.072(0.140)	
Study Economics in college (1/0)	−3.345 (0.669)**	−2.569	−3.346(0.675)***	−2.570
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	−2.814(0.437)***	−0.961
Fair*Group2*Round_C (i.e. 17–24 rounds)	-	-	0.170(0.083)**	0.040
Age (in years)	0.340 (0.077)***	6.477	0.340(0.778)***	6.478
Female (1/0)	0.831 (0.224)***	0.620	0.831(0.229)***	0.620
Group 1 (reference group)				
Group 2 (1/0)	−2.275 (0.450)***	−0.340	−2.361(0.445)***	−0.353
Group 3 (1/0)	−0.587 (0.221)***	−0.088	−0.793(0.211)***	−0.118
Constant	−7.503 (2.198)***		10.399(2.610)***	
Observations	506		506	
R^2	0.38		0.37	
F-Stat	19.25***		17.45***	

Note: The robust standard errors are in parentheses.
**Significant at 5%.
***Significant at 1%.

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

Variables	Coefficient	Marginal effect
Study 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%, respectively.

after the 16th round. This finding nevertheless appears to be consistent with Figures 1–3 and the results of the Mann–Whitney test. Previous public good experiments found significant decline in individual contributions when punishments were withdrawn (see Masclet & Villeval, 2008). Furthermore, the subjects were not conditionally cooperating. Thus, the past average behaviour of the group did not influence the individual's future levels of pollution.

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

Regarding the explanatory variables with significant coefficients, individuals who studied economics at college level were more self-interested, and therefore had 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 the 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. Second, individuals who indicated that it was unfair for Africa to reduce CO_2 emissions had 0.32 higher probability of polluting more in the last eight rounds compared to their first eight rounds. However, we found that within the last eight rounds, when only Group 2 was treated with public disclosure, individuals who were of the view that it is fair for Africa to follow low-carbon development pathways rather polluted more in their group than their counter parts who had the contrasting perception. Spiteful behaviour has been observed in a number of public good experiments (see Fehr & Gächter 2000; Ones & Putterman, 2007; Palfrey & Prisbrey, 1997; Saijo & Nakamura, 1995). Perhaps it is important to emphasize that even if the industrialized nations give substantial financial flows to developing countries as payment for incremental cost of climate change mitigation, such flows could potentially harm the recipient economies by generating volatility, Dutch disease, corruption, and rent-seeking behaviours (Jakob, Steckel, Flachsland, & Baumstark, 2015).

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 the figures (i.e. Figures 1through 3) presented earlier. As a result, there is a strong indication that publicly disclosing pollution levels of individuals could potentially lead to the reduction of emissions.

4. Concluding remarks

Due to inadequate resources and the fear of losing high-abatement-cost industries, African countries typically have lax environmental regulations, which are also weakly enforced. High pollution firms, as a result, gravitate towards the continent. A number of studies have found that non-mandatory information disclosure strategies could generate cost-effective compliance among polluting firms in developing countries. An example of such strategies is the PROPER scheme, which is a public voluntary programme drafted by environmental regulators. Although the scheme has registered some successes, the scope of application is limited, putting into question the extent to which such results are robust.

This study, which seeks to provide additional evidence in an experimental setting, supports the overarching hypothesis that the scheme indeed leads to reductions in carbon emissions, even in a situation where the cost of non-compliance is public shame. Thus, by publicly disclosing an individual's pollution level to the rest of the members of a group, the African climate researchers and decision-makers who participated in the experiment significantly reduced their emission levels, on the average. This indicates that such a public disclosure strategy 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 practice of public disclosure may shame a recalcitrant, and this shaming 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. There is already some evidence, albeit limited, that such

cost-effective schemes have potentials, and our finding appear to support that.

Furthermore, our findings indicate that an individual's perception of fairness regarding Africa's pursuance of low-carbon development pathways determines whether he/she pollutes more. In order to encourage widespread African acceptance of climate mitigation initiatives, the international community should conclusively address the question of climate justice. Without significant investments in achieving such acceptance and in fostering the climate education of relevant policy-makers and general public in the continent, it is likely that aggregate pollution levels within the continent will continue to rise over time.

Surprisingly, individuals who opined that it is fair for Africa to pursue low-carbon development pathways were spiteful (i.e. emit more carbon than their counterparts who perceived it to be unfair), while their counterparts were insensitive to public disclosure of emissions. Nevertheless, since the net impact of perceived fairness on emissions is positive, investing in filling the knowledge gap is necessary.

Finally, 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, the notion that females are more climate/environmentally sensitive than their male counterparts requires further research, as we found evidence to the contrary.

Our sample, though vital, is limited and therefore constrains the extent to which the results could be generalized. In addition to the fact that our sample may not be representative, it is a common worry in experimental economics that there is no full guarantee that, given the same set of conditions, the empirical results obtained may be sustained. Also, the conditions present in the lab experimental setting may not necessarily be the same as what may be present in reality. 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 should be taken seriously.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes

1. In Ghana, for example, 10% of industrial pollution is attributable to mineral extraction and processing (Boocock, 2002).
2. It is also estimated that the continent's ecological systems contribute about 20% of global net primary production and 40% 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).
3. The carbon decomposition analysis typically breaks down carbon intensity (i.e. carbon emission to GDP ratio) into three multiplicative components: energy use to GDP ratio; the ratio of carbon emission to energy use; and ratio of regional to global GDP.
4. In spite of the commendable growth trends registered, African nations have fared poorly on other social indicators such as malnutrition, net primary school enrolment, life expectancy at birth, infant mortality, and inequality (ADR, 2012). The low-carbon development pathways must therefore pursue economic growth and social justice in tandem.
5. Using the figures, the earning equation can be specified as: *Earnings = [US$4.00 × (number of **red** cards you keep)] + [US$1 × (total number of **red** cards collected from the group)]*.
6. Since all the subjects took the course, it was expected that the relative abatement levels would not be significantly impacted.
7. The institutional affiliations of the subjects include the Environmental Conservation Department, the Economic Development Department, the Ministry of Agriculture and Industry, the Department of Economic Development, the Institute for Public Policy Research, the Institute of Social & Economics Research, the Departments of Economic Development, the National Universities, the Forestry Research Institute, the Wildlife Foundation, the Environmental Conservation Department, and the Applied Forestry Research and Development Department.
8. Figure A1 in the appendix presents the frequency distribution of the marks/scores obtained during the experiment. The minimum mean score was 56.7, with a standard deviation of 9.48. Note that the social optimum score was 76.8 points, which is higher than the maximum score of 72.9.
9. The OLS estimation technic was employed because the dependent variable (i.e. the number of red cards retained) is continuous, and we used the log of the data in the estimation that satisfies the OLS assumptions including satisfaction of normal distribution. The diagnostics tests on the data and the results of the regression also supports this assumption. Also, a Logit model was estimated as the second equation because the dependent variable is binary (i.e. whether or not the individual retained more red cards in the last eight rounds than in the first eight rounds) with preference for the logistic distribution over normal distribution because it has heavier tails allowing for a robust analysis of choices in the extreme compared to a normal distribution.
10. This may, however, be an indication that survival concern can supersede concern for climate change impact.
11. This perception of unfairness is underpinned by the fact that Africa contributes marginally to global CO_2 emissions (about 4%), and has not been a major contributor to historical atmospheric greenhouse gas concentrations.

References

Abdulai, A., & Ramcke, L. (2009). *The impact of trade and economic growth on the environment: Revisiting the cross-country*

evidence (Kiel Working Paper No. 1491). Kiel: Kiel Institute for the World Economy.

ADR. (2012). *Toward green growth in Africa*. Retrieved December 28, 2015, from http://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/African%20Development%20Report%202012%20-%20Overview.pdf

Afsah, S., Blackman, A., Garcia, J. H., & Sterner, T. (2013). *Environmental regulation and compulsory public disclosure: The PROPER case in Indonesia: The case of PROPER in Indonesia*. Abingdon: Routledge, Taylor & Francis.

Akpalu, W., Arndt, C., & Matshe, I. (2015). Introduction to the special issue on the economics of climate change impacts on developing countries: Selected studies on Sub-Saharan Africa and South-East Asia. *Sustainability*, *7*(9), 12122–12126.

Akpalu, W., & Johansson-Stenman, O. (2010). Internalized contribution norms and learning in a public goods experiment in Ghana. *Public Finance and Management*, *10*(2), 352–378.

Akpalu, W., & Martinsson, P. (2012). Ostracism and common pool resource management in a developing country: Young fishers in the laboratory. *Journal of African Economies*, *21*, 266–306.

Andreae, M. O. (1991). Biomass burning: its history, use and distribution and its impact on the environmental quality and global climate. In J. S. Levine (Eds.), *Global biomass burning: Atmospheric, climatic and biospheric implications* (pp. 3–21). Cambridge, MA: MIT Press.

Andreoni, J., & Petrie, R. (2004). Public goods experiments without confidentiality: A glimpse into fund-raising. *Journal of Public Economics*, *88*, 1605–1623.

Antweiler, W., Copeland, B. R., & Taylor, S. M. (2001). Is free trade good for the environment? *American Economic Review*, *91*, 877–908.

Ariely, D., Bracha, A., & Meier, S. (2009). Doing good or doing well: Image motivation and monetary incentives in behaving pro-socially. *American Economic Review*, *99*, 544–555.

Baumol, W. J., & Oates, W. E. (1988). *The theory of environmental policy*. New York: Cambridge university press.

Benabou, R., & Tirole, J. (2006). Incentives and pro-social behavior. *American Economic Review*, *96*, 1652–1678.

Bohm, P. (1972). Estimating demand for public goods: An experiment. *European Economic Review*, *3*, 111–130.

Boocock, C. N. (2002). *Environmental impacts of foreign direct investment in the mining sector in sub-saharan Africa*. Paris: OECD.

Bowles, S., & Gintis, H. (2004). The evolution of strong reciprocity: Cooperation in heterogeneous populations. *Theoretical Population Biology*, *65*, 17–28.

Carraro, C., & Lévêque, F. (Eds.). (2013). *Voluntary approaches in environmental policy* (Vol. 14). Dordrecht: Springer Science & Business Media.

Ciais, P., Bombelli, A., Williams, M., Piao, S. L., Chave, J., Ryan, C. M., … Valentini, R. (2011). The carbon balance of Africa: Synthesis of recent research studies. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *369*(1943), 2038–2057.

Dam, L., & Scholtens, B. (2008). Environmental regulation and MNEs location: Does CSR matter? *Ecological Economics*, *67*(1), 55–65.

Dasgupta, S., Mody, A., Roy, S., & Wheeler, D. (1995). *Environmental regulation and development: A cross-country empirical analysis* (World Bank Discussion Papers #1448). Washington, DC: World Bank.

Davies, T., & Mazurek, J. (1996). *Industry incentives for environmental improvement: Evaluation of US federal initiatives*. Washington, DC: Global Environmental Management Initiative.

Fehr, E., Fischbacher, U., & Gächter, S. (2002). Strong reciprocity, human cooperation, and the enforcement of social norms. *Human Nature*, *13*(1), 1–25.

Fehr, E., & Gächter, S. (2000). Cooperation and punishment in public goods experiments. *American Economic Review*, *90*, 980–994.

Fischbacher, U., & Gächter, S. (2010). Social preferences, beliefs and the dynamics of free riding in public good experiments. *American Economic Review*, *100*, 541–556.

Fischbacher, U., Gächter, S., & Fehr, E. (2001). Are people conditionally cooperative? Evidence from a public goods experiment. *Economics Letters*, *71*, 397–404.

Garcia, H. J., Afsah, S., & Sterner, T. (2009). Which firms are more sensitive to public disclosure schemes for pollution control? Evidence from Indonesia's PROPER program. *Environment and Resource Economics*, *42*, 151–168.

Garcia, H. J., Sterner, T., & Afsah, S. (2007). Public disclosure of industrial pollution. The PROPER approach for Indonesia? *Environment and Development Economics*, *12*(6), 739–756.

Garibaldi, J. A., Winkler, H., La Rovere, E. L., Cadena, A., Palma, R., Sanhueza, J. E., … Torres Gunfaus, M. (2014). Comparative analysis of five case studies: Commonalities and differences in approaches to mitigation actions in five developing countries. *Climate and Development*, *6*(Suppl. 1), 59–70.

Gächter, S., Herrmann, B., & Thöni, C. (2010). Culture and cooperation. *Philosophical Transactions of the Royal Society B*, *365*, 2651–2661.

Habtezion, Z. (2012). *Overview of linkages between gender and climate change*. (Lance W. Garmer Ed.). NY: United Nations Development Programme (UNDP).

Herrmann, B., & Thöni, C. (2009). Measuring conditional cooperation: A replication study in Russia. *Experimental Economics*, *12*, 87–92.

Herrmann, B., Thöni, C., & Gächter, S. (2008). Anti-social punishment across societies. *Science*, *319*, 1362–1367.

Holt, C. A., & Larry, S. K. (1997). Classroom games: Voluntary provision of a public good. *Journal of Economic Perspectives*, *11*(4), 209–215.

Houghton, J. T., Ding, Y. D. J. G., Griggs, D. J., Noguer, M., van der Linden, P. J., Dai, X., … Johnson, C. A. (2001). *Climate change 2001: The scientific basis*. Cambridge: The Press Syndicate of the University of Cambridge.

IEA. (2012). *IEA Energy Statistics*. Retrieved December 12, 2014, from http://www.iea.org/statistics/

Isaac, R. M., Walker, J. M., & Williams, A. W. (1994). Group size and the voluntary provision of public goods: Experimental evidence. *Journal of Public Economics*, *54*, 1–36.

Jakob, M., Steckel, J. C., Flachsland, C., & Baumstark, L. (2015). Climate finance for developing country mitigation: Blessing or curse? *Climate and Development*, *7*(1), 1–15.

Jorgensen, B. S., & Syme, G. J. (2000). Protest responses and willingness to pay: Attitude toward paying for stormwater pollution abatement. *Ecological Economics*, *33*(2), 251–265.

Khanna, M. (2001). Non-mandatory approaches to environmental protection. *Journal of Economic Surveys*, *15*(3), 291–324.

Kocher, M., Cherry, T., Kroll, S., Netzer, R., & Sutter, M. (2008). Conditional cooperation on three continents. *Economic Letters*, *101*, 175–178.

Korkala, E. A. E., Hugg, T. T., & Jaakkola, J. J. K. (2014). Awareness of climate change and the dietary choices of young adults in Finland: A Population-based cross-sectional study. *PloS one*, *9*(5), 1–9.

Laporte, N., Merry, F., Baccini, A., Goetz, S., Stabach, J., & Bowman, M. (2007). *Reducing CO_2 emissions from deforestation and degradation in the Democratic Republic of Congo: A first look*. Falmouth, MA: The Woods Hole Research Center.

Maibach, E., Bloodheart, B., & Zhao, X. (2013). *Perceptions of extreme weather and climate change in Virginia: A statewide survey of adults*. Center for climate change communication, George Mason University, Fairfax, VA.

Martinsson, P., Pham-Khanh, N., & Villegas-Palacio, C. (2013). Conditional cooperation and disclosure in developing countries. *Journal of Economic Psychology*, *34*, 148–155.

Marwell, G., & Ames, R. E. (1979). Experiments on the provision of public goods I: Resources, interests, group size, and the free rider problem. *American Journal of Sociology*, *84*, 1335–1360.

Masclet, D., & Villeval, M. C. (2008). Punishment, inequality, and welfare: A public good experiment. *Social Choice and Welfare*, *31*, 475–502.

Maxwell, J. W., Lyon, T. P., & Hackett, S. C. (2000). Self-regulation and social welfare: The political economy of corporate environmentalism. *Journal of Law and Economics*, *XLIII*(2), 583–618.

McCright, A. M. (2010). The effects of gender on climate change knowledge and concern in the American public. *Population and Environment*, *32* 66–87.

Mundaca, L., Markandya, A., & Nørgaard, J. (2013). Walking away from a low-carbon economy? Recent and historical trends using a regional decomposition analysis. *Energy Policy*, *61*, 1471–1480.

Nikiforakis, N., & Normann, H. T. (2008). A comparative statics analysis of punishment in public goods experiments. *Experimental Economics*, *11*, 358–369.

Noussair, C., & Tucker, S. (2007). Public observability of decisions and voluntary contributions in a multi-period context. *Public Finance Review*, *35*, 176–198.

Olsson, L., Opondo, M., Tschakert, P., Agrawal, A., Eriksen, S. H., Ma, S., ... Zakieldeen, S. A. (2014). Livelihoods and poverty. In C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, … L. L. White (Eds.), *Climate Change 2014: Impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects. Contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change* (pp. 793–832). Cambridge: Cambridge University Press.

Ones, U., & Putterman, L. (2007). The ecology of collective action: A public goods and sanctions experiment with controlled group formation. *Journal of Economic Behavior & Organization*, *62*(4), 495–521.

Palfrey, T. R., & Prisbrey, J. E. (1997). Anomalous behavior in public goods experiments: How much and why? *The American Economic Review*, *87*, 829–846.

Rege, M., & Telle, K. (2004). The impact of social approval and framing on cooperation in public good situations. *Journal of Public Economics*, *88*, 1625–1644.

Saijo, T., & Nakamura, H. (1995). The "spite" dilemma in voluntary contribution mechanism experiments. *Journal of Conflict Resolution*, *39*(3), 535–560.

Segerson, K., & Miceli, T. J. (1998). Voluntary environmental agreements: Good or bad news for environmental protection? *Journal of Environmental Economics and Management*, *36* (2), 109–130.

Smulders, S., & Gradus, R. (1996). Pollution abatement and long-term growth. *European Journal of Political Economy*, *12*(3), 505–532.

Soetevent, A. R. (2005). Anonymity in giving in a natural context: An economic field experiment in thirty churches. *Journal of Public Economics*, *89*, 2301–2323.

Storey, M., Boyd, G., & Dowd, J. (1999). Voluntary agreements with industry. In C. Carraro & F. Leveque (Eds.), *Voluntary approaches in environmental policy* (pp. 187–207). Dordrecht: Kluwer Academic.

Thöni, C., Tyran, J. R., & Wengström, E. (2009). *Micro-foundations of social capital* (Discussion paper 09–24). Department of Economics, University of Copenhagen.

Vorster, S., Winkler, H., & Jooste, M. (2011). Mitigating climate change through carbon pricing: An emerging policy debate in South Africa. *Climate and Development*, *3*(3), 242–258.

Zhang, X. (2010). *Analysis of the results of Environmental Performance Rating and Disclosure for Pollution Control Program in ChangShu, China: Debates and implementation of corporate social responsibility and entrepreneurial strategies*. Unpublished. Retrieved February 15, 2015, from http://www.kadinst.hku.hk/sdconf10/Papers_PDF/p174.pdf

Appendix 1

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 you, and you will play 4 of your 8 cards by placing these 4 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$4.00) 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 CO2. The net benefits (benefits – costs) your industry receives is four dollars (US$4.00). 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$0.00) 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$1.00). This represents the gains to society from the avoidance of global warming (e.g. avoidance of sea level rise, skin cancers, 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$4.00 × (number of **red** cards you keep)] + [US$1 × (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) # of red cards you keep	(B) value of red cards	(C = A × B) points for red cards kept	(D) total # of red cards not kept	(E) value of red cards not kept	(F = D × E) earnings for red cards not kept	(G = C + F) total earnings this round
1		$4			$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 FOUR of your 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 pathways? Yes or No.
(11) What is your Gender? Male or Female.
(12) What is your age? …

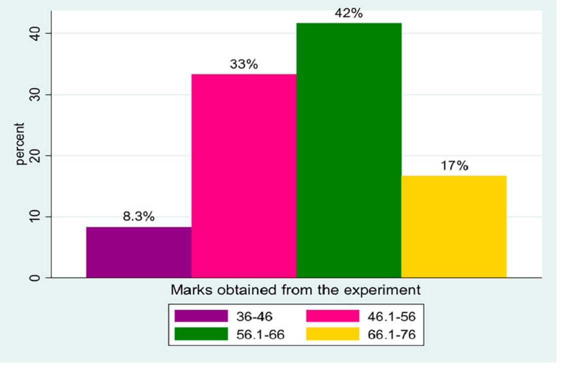

Figure A1. Frequency distribution of scores (marks) obtained in the experiment.

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