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USING INFORMATION TO IMPROVE GLOBAL COOPERATION: A CLIMATE CHANGE EXPERIMENT

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Abstract

We run an experiment in five countries with 7,132 participants to study how information on the contribution of others influences contributions to climate change mitigation. Participants receive artificially generated information on the average contribution of others, on the ranking of contributions and endowments of others, and on others' nationalities. We show that (i) participants from developed countries free ride on the average of others, whereas participants from developing countries follow the lead of the majority; (ii) information on the ranking of contributions increases participants' contributions as compared to information on the average of others; and (iii) participants dislike to be in the first and last position of the contribution ranking. Our results suggest that a country's contribution to climate change mitigation can be promoted by using information on the contributions of other countries.[1]

JEL: H41; Q54; Q58; C90
Keywords: Climate Change, Multi-country study, Bargaining.

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1 Introduction

It has been shown that an individual's contribution to public good provision is influenced by the contributions of others (Erev et al. (1993), Frey and Meier (2004), Shang and Croson (2009) and Augenblick and Cunha (2015)). The behavioural economics literature has identified different motivations or effects—such as conditional cooperation, (Fischbacher et al. (2001)), competitive motivation (Bornstein et al. (2002)) and follow the leader effect (Jack and Recalde (2015))—that lead to increased provision of public goods in different settings.

Climate change mitigation requires global cooperation. No single country alone is able to provide the required reduction in greenhouse gas emissions to avoid catastrophic climate change. However, as in the standard public good game setting, cooperation obstacles, such as free-riding, may prevent countries to reach a socially optimum equilibrium (Milinski et al. (2008) and Schmidt and Ockenfels (2021)).[2] Analogously to the case of an individual's contribution to public good, a potential way to improve global cooperation is to use the behaviour of other countries to influence a single country. Information on the contribution of others might increase an individual country's contribution to climate change mitigation.

We run an online experiment in five countries—the US, the EU[3], China, South Africa and India—to study how information on the contribution of others influences contributions to climate change mitigation. We instruct around 7,000 participants to behave the way they think their own countries should in a climate change negotiation.[4] We then give tokens to participants and ask them to allocate these tokens into a private account and public account, which is the climate change mitigation account. Our experiment has four treatments, in which we vary the type of information of what participants believe to be the contribution of others. Our results show that (perceived) contribution of others change a participant's contribution to climate change mitigation, and might lead to overall increased contributions.

Our experiment mimics a threshold public good game with a climate change framing (see Brick and Visser (2015) and Tavoni et al. (2011)). Participants do not interact with each other, but they believe they are playing a game with four other participants of different countries. By employing a game-like payoff structure and framing, we elicit participants' preferences with regards to climate change mitigation. At every round of every treatment—apart of treatment 1[5]—participants know the payoff of each of their potential contribution

[2]The seminal work of Barrett (1994) discusses the main theoretical obstacles for global cooperation in the case of international environmental agreements, and climate change specifically.

[3]EU countries are: Germany, Poland, France, Italy and Spain.

[4]The assumption here is that, in an international negotiation, political leaders have preferences which are aligned to the preferences of their country's population. This is why we do our best to have a nationally representative sample in the five countries of the experiment. As our descriptive statistics show, the samples are representative with regards to age and gender.

[5]In treatment 1, participants do not receive any information about payoffs or contribution of others.

choices, and whether the climate change threshold is met. Moreover, participants receive information—which is artificially generated—about what others are doing: in treatment 2, they see the average of the other four participants; in treatment 3, they see a ranking order of both contribution and endowments of others; and in treatment 4, they see the same ranking order as before, now with participants' country names.

Our results shed light on how the contribution of others might influence global public good provision of climate change mitigation. We have four main findings. First, participants from developed countries decrease contribution to climate change mitigation as the average of others increase; whereas participants of developing countries increase contributions with the average of others. Second, the ranking order information, where both contributions and endowments of others are shown, increases contributions to mitigation as compared to the information on the average of others. Third, both the last and first ranking contributions increase participants' contribution to climate change. Finally, the nationality of other participants does not change a participant's contribution, on average.

Therefore, if political leaders are aligned with the preferences of the general population of their countries, our results suggest that information on the contribution of other countries can foster climate change mitigation. Behavioural effects, such as follow the lead of others and what we call the shame effect, might be able to motivate countries to contribute more than they would in a situation of no information about what other countries do.

This paper is related to the recent work that investigates behavioural effects associated to climate change mitigation (Perino et al. (2014), Dannenberg et al. (2021) and Bruns and Perino (2021)); and, more broadly, to the climate change cooperation literature (Wu and Thill (2018), Nordhaus (2021) and Schmidt and Ockenfels (2021)). We also build on the literature of threshold public good games with heterogeneous endowments to create the design of our experiment (Milinski et al. (2008), Brick and Visser (2015) and Brekke et al. (2017)). Our results also contribute to the literature of the economics of environmental agreements (see e.g. Barrett (1994), Wu and Thill (2018) and McGinty (2020)).

The remainder of the paper is structured as follows. Section 2 places our work in the current literature. Section 3 describes our experiment. Section 4 presents the results. The last section concludes our paper.

2 Literature Review

Our study belongs to the literature that examines how the perceived behaviour of others affects contributions to public good provision (Bornstein and Ben-Yossef (1994), Bornstein et al. (2002), Shang and Croson (2006), Kessler (2017) and Dannenberg et al. (2021)).

It has been shown that people's contribution to public goods are influenced by the contribution of others. For example, individuals can match past and current contribution of others, increasing their own contributions, the so called

'conditional cooperation' (Fischbacher et al. (2001)); or they can increase contributions because they see other individuals as competitors, which is usually called 'competitive motivation' (Bornstein et al. (2002) and Bergantino et al. (2021)). Moreover, individuals might increase public good provision if leaders in their communities do so, the 'follow the leader' effect (Jack and Recalde (2015) and Beekman et al. (2014)). We highlight three studies from this literature.

Fischbacher et al. (2001) devise an one-shot public good game to elicit participants' willingness for conditional cooperation. Their results show that a third of the participants are free riders and half of them are conditional cooperators. In our experiment, conditional cooperation happens when participants increase contributions as the average of others increase. Bornstein et al. (2002), on the other hand, investigate whether competition between groups of players might improve coordination within a group, and increase public good provision. Their results show that inter-group competition can in fact improve collective efficiency as compared to no competition. We do not test competitive motivations in our experiment, however. Finally, Jack and Recalde (2015) run a field experiment in rural Bolivia to investigate the impact local leaders have on voluntary public good provision. They find that people's contributions increase with leaders' contributions. This is in line with our results, which show that the contribution of the first player in the ranking order increases average contributions to climate change mitigation.[6]

This paper is also closely related to recent experimental work that investigates some of the behavioural effects associated to contributions to climate change mitigation. Perino et al. (2014) look at how intrinsic motivation and regulatory interventions interact in the context of supermarket consumers in the UK. They find that information provided via a label increases contributions to climate change mitigation (in the form of buying products with a smaller carbon footprint). Similarly, Bruns and Perino (2021) implement an online experiment in Germany to measure the impact of recommendation, default and mandatory minimum contribution on climate protection. They find that mandatory minimum contribution treatment can increase average contribution of participants. Overall, our results also show that a behavioural intervention—giving information on the contribution of other countries—might be used to increase climate change contributions.

Our experimental design builds on the literature of public good games applied to climate change prevention and mitigation. Unlike the standard public good games that focus on the creation of a collective gain[7], climate change implies investing in a public good to avoid a loss. As a result, these games incorporate thresholds and probabilistic losses if the target is missed.

We incorporate elements of the design of three papers in this literature.[8]

[6]Our study is also related to the theoretical literature that examines 'relative concerns'—that is, when concerns linked to how much others are consuming or investing enter an individual's utility function. Two recent studies by Aronsson and Johansson-Stenman (2014b) and Aronsson and Johansson-Stenman (2014a) show that the inclusion of relative concerns can change the equilibrium provision of public goods.

[7]See e.g. Fischbacher and Gächter (2010) and Guererk et al. (2010).

[8]We follow Isaac and Walker (1998) and use a quadratic public good return function in our experiment to generate an interior Nash Equilibrium.

Milinski et al. (2008) introduce what is called the 'collective-risk social dilemma' and simulate it in a repeated experiment with fixed targets and several groups of participants. They find that, when there is high risk of catastrophic climate change, half of their groups are able to reach the target. Using a similar design, Tavoni et al. (2011) find that endowment inequality reduces chances to reach the target, but that allowing for communication between participants increases the likelihood of a successful coordination. In Brick and Visser (2015), participants are asked to represent different countries—with different initial endowments—and to play a public good game. The game has a climate change framing, a threshold, and real monetary incentives.

It is important to mention that we do not make participants play a public good game. We use a public good framing and its payoff structure to elicit participant's preferences towards climate change mitigation.

More broadly, our work belongs to the literature of the economics of environmental agreements applied to climate change (see e.g. Barrett (1994) and Nordhaus (2019)). This body of work examines the cooperation and coordination obstacles for countries to provide socially optimum levels of global public goods (McGinty (2020)). In particular, free-riding in climate change mitigation—when a country receives the benefits of mitigation without contributing to the costs—is extensively studied in this literature.

3 Experiment

Our experiment mimics a threshold public good game with a climate change framing. We use a similar design to Brick and Visser (2015), where there are five players, a threshold for catastrophic climate change (implying a penalty to returns from both the private and public accounts), and heterogeneous endowments. We employ a game-like framing instead of running a game itself because we are mainly interested in eliciting participants' preferences with regards to climate change mitigation. This set-up enables us to break down participants' choices into various components linked to the way in which participants respond to the perceived behaviour of others.

In this section, we describe the design of the experiment, parameters and framing, our four treatments, the sample of participants, and procedures. Our experiment was designed in 2017 and implemented in 2018.[9]

3.1 Design

Our design builds on the strategy-method proposed by Fischbacher et al. (2001), but departs from theirs by: (i) introducing a threshold, (ii) changing the reference group and varying the information regarding the contribution of others

[9]All the materials of the experiment were submitted to the the Ethics Committee of the Graduate Institute of International and Development Studies (IHEID). The ethical approval to implement it was granted in May 2017.

and (iii) allowing the existence of multiple interior Nash equilibria.[10]

Participants are endowed with a certain amount of tokens, depending on their nationality, and are asked to allocate these tokens between a private and a public account. Participants are told that they should behave the way they think their own countries should behave in a climate change negotiation. Provided the aggregate allocation towards the public account reaches a known pre-set threshold T, each player receives whatever they invested in their private account plus an equal share of the public good returns, regardless of their contribution. If the threshold is not met, participants will retain a portion λ of their total return. Player i's earnings are given by,

$$\Pi_i = \begin{cases} (E_i - g_i) + \frac{\left(\delta G - \gamma G^2\right)}{n} & if \quad \sum_1^n g_j \geq T \\ \left[(E_i - g_i) + \frac{\left(\delta G - \gamma G^2\right)}{n}\right] \lambda & if \quad \sum_1^n g_j \leq T \end{cases} \tag{1}$$

where g_i is individual contribution, G is the aggregate level of public good[11], δ and γ are the parameters of the quadratic return function, and n is the number of players in the group. Following Brick and Visser (2015) and Brekke et al. (2017), heterogeneity in wealth is introduced by asymmetric initial endowments, E_i. Endowment allocations are chosen so that the more developed the country, the more tokens players receive.

Note that, in all rounds of treatments 2, 3 and 4, the payoff of each potential choice is shown to participants before they make their contribution. They also know whether their potential choice meets the climate change threshold.[12] In each round of these treatments, we artificially generate values for the contribution of other players g_{-i} so that each participant has all this information available to her. Payoffs are shown in tokens, and there is always a contribution choice that maximises a participant's payoff. At the end of the experiment, participants receive a financial compensation which is proportional to their average payoff (in all treatments and rounds), so that we have an incentive compatible environment.

3.2 Parameters and Framing

Table 1 presents the parameter values we use in our experiment. This set of parameters implies that the social optimum of climate change mitigation—when the marginal costs is equal to the marginal social benefits—is achieved when total contribution is equal to 116 tokens.

The parameters of the payoff function were chosen following Brick and Visser (2015), and using data from the CAIT Data Explorer (2017). Following

[10]The standard public good experiment assumes linear payoffs, implying an unique dominant strategy equilibrium of individual free riding and a group optimal of full cooperation (Willinger and Ziegelmeyer (2001)). We introduce a quadratic payoff structure to allow the Nash Equilibrium to fall in the interior of the feasible contributions set.

[11]$G = \sum_1^n g_j$.

[12]See Figure 4 in Appendix B for an example.

these two sources, we considered that, in 2012, emission levels of the 5 countries of our experiment summed up to 25,085 MtCO_2; and we assumed that, by 2050, greenhouse gas emissions should be reduced to 62 MtCO_2 to avoid catastrophic climate change.[13] To select each country's endowment, we also followed Brick and Visser (2015), changing the numbers but keeping the same distribution.

After the initial screening questions, participants are introduced to the topic of the experiment. They are told that one serious problem facing their respective country is to decide 'how much to invest in climate change mitigation'. We give them a short explanation on what 'climate change mitigation' means, and then tell them that, in this experiment, they should decide how much to invest in mitigation the same way they think their countries should do.

Table 1: Parameter Values of the Payoff Function

Parameter	**Value**
Payoff Function	
n	5 players
T	36 tokens
δ	6.1
γ	0.022
λ	0.5
Endowment, E_i	
US	30 tokens
EU	20 tokens
China	12 tokens
South Africa	10 tokens
India	8 tokens

Following this first slide, we have a second slide in which we briefly explain what climate change is, its catastrophic effects, and the requirement for all countries to cooperate to reach a global solution. We also tell participants that different countries are in different economic stages, and they have different endowments to invest in climate change mitigation. We finish this set of introductory slides by explaining what the threshold means, that the benefits of meeting the threshold are equally shared among countries, and that catastrophic climate change results in a loss to every country in the world.

The second set of slides tells participants that they need to allocate their tokens in the private and public accounts, and explains how their own payoff varies with meeting the threshold. Figure 3 in Appendix A presents the most important slide of this part of our experiment, in which an example of the payoff structure in shown to participants. For each potential choice—each participant has six contribution choices in every treatment and round—there is a payoff in tokens below, and information on whether the threshold is met.

[13]Note that we excluded emissions from land use and forestry from these figures.

A concern of ours when implementing the experiment was to ensure that our framing is simple enough for participants to fully understand it. Two pieces of evidence confirm that the vast majority of our participants provide meaningful answers to our experiment. First, few participants show any sign of confusion after the experiment is finished. We only have around 12% of confused participants—that is, participants who leave a comment saying that they have problems understanding the experiment.[14] Second, only around 3.7% of our participants state that 'they do not know about climate change'. This suggests that climate change mitigation was not a new topic for them.

3.3 Treatments

Our experiment has four treatments in total:

T1 - Unconditional contribution Participants decide how much to contribute to climate change mitigation, without knowing the contribution of other players, the payoff of each of their choices and whether the threshold is met.

T2 - Average contribution Participants decide how much to contribute to climate change mitigation, given the average contributions of other players (which is randomly generated), the payoff of each potential contribution choice, and information on whether the threshold is met.

T3 - Ranking of Contributions Participants decide how much to contribute to climate change mitigation, given the ranking of contributions of other players (which is randomly generated), payoff of each contribution choice, and information on whether the threshold is met. Note that the ranking is showed to participants with the contribution of each player followed by her endowment.[15]

T4 - Ranking of Contributions with Country Names This last treatment is exactly equal to the previous one, with the only difference that now participants see the country labels next to each contribution.[16]

Again, note that participants are neither interacting nor playing a game. They are presented with information on hypothetical contributions of other

[14] We encouraged participants to do so if they felt confused during the experiment. We also identify 'speeders', that is, participants who finish the experiment in less than 48% of the median time. They are around 8% of our sample. Unlike confused participants, we cannot say with certainty that speeders do not understand our experiment.There is only a small overlap of 54 participants who are both confused and speeders.

[15] Player names are labelled as follows: 'Player 1', 'Player 2', 'Player 3' and 'Player 4'.

[16] Figure 4 in Appendix A shows an example of this last treatment.

players and are aware of their exact payoff for each possible contribution.[17] Participants do not know that they are not interacting with other players.

The order of the treatment section follows what is outlined above: participants start with T1, then T2, T3 and finish the experiment with T4. Each participant has to complete two rounds of treatments—in each of these rounds, the payoff structure, threshold level and contribution choices are the same.[18]

In T2, T3 and T4, we have four scenarios that occur with a probability of 25% each:

- A situation in which all other countries give about the same percentage of their endowments to climate change mitigation;
- A situation in which developed countries (the EU and US) free ride and give little of their endowments to climate change mitigation;
- A situation in which the developed countries lead by giving a substantial amount of their endowments, and developing countries give little;
- A situation where the most developed country (either the US or EU) free rides and the others give substantial amounts of their endowments to mitigation.

The specific figures of each of these scenarios are chosen randomly.

3.4 Sample

The sample consists of individuals from the United States (n=1,540), the EU (n=1,542), China (n=1,533), South Africa (n=1,076), and India (n=1,540). The EU sample is made up of individuals from Germany, France, Italy, Spain and Poland. The survey was translated into six languages in addition to the original English version so that it could be run in the native language of all participants. We required participants to possess at least a university degree to ensure understanding of the framing of the experiment, except in South Africa, where some individuals with high school equivalency were accepted due to problems obtaining enough participants.

Quotas are implemented for two main variables, age and gender, to make our sample as representative as possible of each country population.[19] As Tables 8 and 9 show in Appendix A, at least for these two variables, our sample is

[17] As we mention before, the objective of the experiment is to elicit preferences. This is comparable to other experiments with conditional cooperation, where players know the strategy that maximises their payoff, but still deviate from it (see e.g., Augenblick and Cunha (2015) and Fischbacher et al. (2001)).

[18] Apart from T1, in which participants do not have any information on payoff structure.

[19] For the South African and Indian samples, we also attempted to implement quotas for ethnic groups and castes. For the US sample, we also implement a quota on political party affiliation (due to the fact that this variable is highly correlated to attitudes towards climate change (see e.g. McCright and Dunlap (2011)).

roughly representative. The sample becomes less representative when we examine other variables, such as party affiliation and ethnic group. In Appendix A, we present detailed descriptive statistics of our sample.

The vast majority of our participants either 'know something' or 'know a lot' about climate change. For each of the five countries, more than 70% of the participants state that they are either 'very concerned' or 'concerned' about climate change. Finally, more than 60% of participants believe that climate change is occurring and it is caused by human activities.[20] This indicates that climate change mitigation is a salient topic for most of our participants and that they were meaningfully engaged in the experiment.

3.5 Procedures

After designing the experiment, we selected a market research firm 'Lightspeed Research' through a competitive tender process to implement data collection. Lightspeed Research has large pools of potential participants in the five countries where we ran the experiment. Potential participants received an email from the firm and chose to participate in the experiment voluntarily. We instructed the firm to let participants know that they would get a financial reward from participation, and that they could stop the experiment at any point if they wanted to.

The experiment was then conducted through an online survey in these five countries, within an interval of two months. After all treatments were concluded, participants completed a short survey that captured demographic information and climate change knowledge. Participants were paid through their online accounts with Ligthspeed Research after they finished answering all questions. Participants were also given the opportunity to comment on whether they understood the experiment at the end.

4 Results

We now examine participants' choices, and relate these choices to the information they receive in each treatment. We focus on how the perceived behaviour of others—the artificially generated average contribution of others and ranking order—changes participants' contribution to climate change mitigation.

We show that the perceived behaviour of others influences participants' contribution to climate change mitigation. This perception can either increase or decrease average contributions depending on (i) the nationality of the participant, (ii) the type of information received (ranking order or average of others), and (iii) the size of a participant's unconditional contribution.

[20]Tables 14, 15 and 16 in Appendix A summarise these figures for each country in our sample.

4.1 Unconditional Contributions

4.1.1 Contributions

Our first treatment was designed to measure participants' willingness to contribute to climate change without having any knowledge about payoffs or contribution of other participants. This scenario mimics a situation pre climate change negotiation in which countries do not know how other countries behave, and it is also difficult for them to estimate the gains from climate change mitigation. This first set of results serves as a baseline to examine the effects of the average contribution of others and the ranking order on participants' contribution.

Table 2 presents the average contribution of participants of each country as a percentage of their individual endowment. India leads the ranking of contributions, followed by South Africa, European Union, China, and the US. Although differences are small in magnitude and close to the middle choices of each country[21], contributions are statistically different among each other.

Table 2: Contributions to Climate Mitigation as a Percentage of Endowment (T1)

Country	% Endowment
EU	58.13
	(24.64)
US	54.84
	(28.39)
RSA	61.58
	(25.42)
China	56.89
	(23.96)
India	63.23
	(27.38)

Standard errors in parentheses.

These results can be linked to some of the characteristics of the participants of our experiment. In particular, the size of these unconditional contributions might be explained by variables that capture participants' beliefs towards (i) climate change as something that is happening and is a threat; (ii) humanity's capacity to solve the issue; and (iii) trust on the agents responsible for putting forward a solution.

We run an OLS regression of some of these key characteristics on the percentage of endowment contributed. Results are shown in Table 17 in Appendix B. As it was expected, climate change concern is the largest determinant of contributions: on average, participants who are 'very concerned' about climate change contribute 35.5% more than participants who are 'not concerned at all'.

[21]'Middle choices' are equal to either 40% or 60% of participants' endowments (participants had six potential contribution choices).

Note that the ranking of contributions in Table 2 follows the climate change concern ranking, with the sole exception of Chinese participants.[22]

Self-reported knowledge of climate change (from 'I don't know anything' to 'I know a lot') and belief on climate change ('is climate change occurring?') are not correlated to amount contributed. On the other hand, trust on foreigners and belief on whether national governments should solve international problems are both positively correlated to contributions. Thus, it appears that participants who believe that climate change is a major problem but it is solvable contribute more to mitigation than other participants.

Overall, results indicate, in a situation of little information, participants are cautious with regards to their contributions—on average, they choose a focal point (middle contribution choice), with small variations that are proportional to their perception of how severe climate change is.

4.1.2 Mapping Participants' Types

T1 may also be used to characterise participants with respect to the norm they follow when dealing with climate change mitigation. We define two categories of participants: (i) purely rational participants and (ii) collective problem solvers.

A purely rational participant is someone who contributes with exactly zero tokens in T1. This participant is not concerned about climate change mitigation when there is no information about what other participants are doing or about collective payoffs. A collective problem solver, on the other hand, is a participant who contributes with exactly all her tokens in T1. She is fully committed to solve the climate change problem, and puts little weight on her private payoff. Most participants in our experiment are in between these two categories.

Figure 1 plots the distribution of types of participants per country. The US has the largest proportion of purely rational participants, around 6%, followed by the EU with 2%, China, South Africa and India, with 1% each. As it is expected by the proportion of participants concerned with climate change, India has the largest proportion of collective problem solvers, 17%, followed by South Africa, 16%, the US, 14%, the EU, 12% and China, 8%.

The main question that permeates our empirical analysis is the following: how does new information given to participants in treatments 2, 3 and 4 change their types? We expect that, as participants learn about payoff structure and form beliefs about what others are doing, the proportions in Figure 1 might change. We come back to this issue in section 4.4.

4.2 Average Contribution of Others

In treatment 2, participants receive three pieces of information: (i) the payoff of each of their contribution choices, (ii) the average contribution of other participants, and (iii) the required amount of contribution to avoid disastrous climate change. With this new information, participants can adjust their contributions

[22] 91% of Indian participants are 'very concerned' or 'concerned' about climate change, followed by participants from China, 88%, South Africa, 82%, EU, 77% and US, 68%.

Figure 1: Types of Participants (% of Endowment in T1)

as compared to T1. We now look at if and how this adjustment happens, with an emphasis on the impact of the average contribution of other countries.

There are three behaviour effects associated to adjustment. An individual participant can: (i) free ride—to decrease her contribution as the average of others increases; (ii) follow the lead of others—to increase her contribution as the average of others increase; or (iii) simply keep the same contribution as in T1.

We start by examining how the average of others change the likelihood of a participant to increase her contribution. We run one probit regression per country. The dependent variable is binary, *increase in contributions as compared to T1*, and the independent variables are *choice payoff* (the payoff in tokens of the choice made) , *threshold* (whether the threshold is met or not), and *average contribution of others* (in number tokens), which is our variable of interest.[23]

Table 3 presents the coefficients associated to the *average contribution of others* variable for each country. An increase of one token in the average of others decreases the likelihood of increasing contributions by 1.75% and 1.86% for the EU and US, respectively. This means that participants of developed countries are, on average, free riding. The average of others has a positive impact on the contribution of participants of developing countries, however—an increase of one token increases the likelihood of contributing more than in T1 by 6.32%, 11.43% and 19.09% for South Africa, China and India, respectively. This means that participants of these countries follow the lead of others.

[23]We also run the same regressions with two controls, age and gender; and a linear probability model with fixed effects for each round. The results remain the same.

Table 3: Effect of the Average Contribution of Others on T2 contributions – Margins of Probit Regressions

Country	% Effect on Likelihood of Increasing Cont.
EU	-1.75
	(0.91)
US	-1.86
	(0.57)
RSA	6.32
	(2.59)
China	11.43
	(1.74)
India	19.09
	(2.33)

Standard errors in parentheses.
All results are statistically significant at 1%.
Observations: EU - 3,084, US - 2,942, India - 3,080, South Africa - 2,152 and China - 3,068.

We can investigate the free riding effect further by restricting our sample to situations in which the average of others in T2 was larger than participants' T1 contribution. We know that this happened 46.5% of times—that is, the average of others that participants see in their screen is larger than their T1 contribution—and in 57% of these cases, participants decrease their contributions (as compared to T1).

Table 4: Effect of the Average Contribution of Others on T2 contributions, Restricted Sample – Margins of Probit Regressions

Country	% Effect on Likelihood of Decreasing Cont.
EU	25.76
	(4.22)
US	13.28
	(3.48)
RSA	18.27
	(2.68)
China	34.03
	(2.53)
India	9.24
	(2.32)

Standard errors in parentheses.
All results are statistically significant at 1%.
Observations: EU - 483, US - 359, India - 2,605, South Africa - 1,433 and China - 1,781.

Table 4 shows the coefficients for the likelihood of decreasing contributions

when participants see a larger average of others than their T1 contribution. In this particular situation, participants of all countries free ride, that is, the likelihood of decreasing contributions as compared to T1 is positive. Participants from China present the largest coefficient, whereas Indian participants have the smallest one—a increase of one token in the average of others increases the probability of Indian participants to decrease contributions in 9%.

The results of this section suggest two things. First, on average, participants from developed countries free ride on the average of others, whereas participants from developing countries follow the lead of others. A possible explanation to this outcome is that developing countries tend to be less influential than developed countries when it comes to climate change negotiations. Because of that, participants of developing countries would be inclined to follow the majority more often.

Second, in the specific case in which the average of others is large (as compared to the contribution in T1), participants of all countries free ride. It appears that a large average of others allows participants to be more rational, that is, to care less about the collective returns of climate change mitigation. This is illustrated by the fact that, on average, around 14% of times participants maximised their payoffs in T2; this number goes to 26% when we only consider T2 cases in which the average of others is larger than T1 contribution choices.

To end this section, we examine the subjective drivers of the adjustment participants make. We regress the binary variable *increase in contributions as compared to T1* on participants' characteristics with regards to climate change and trust.[24]

Results are shown in Table 18 in Appendix B. The more concerned participants are about climate change and the more they believe in it, the larger is the likelihood of increasing contributions as the average of others increase. These are the two most important determinants on whether participants follow the lead of the majority. Frequency of travel abroad is negatively correlated to increase in contributions. Finally, trust on foreigners is not correlated to an increase in contributions.

The results of this section indicate that information about the average contribution of others change contributions to climate change mitigation. The nature of this change depends on the size of the average contribution of others as compared to a participant's unconditional contribution, to a participant's nationality, and to how concerned the participant is about climate change.

4.3 Ranking Order

4.3.1 Without Country Names

In treatment 3, participants also receive three pieces of information: (i) the payoff of each of their contribution choices, (ii) the required amount of contributions to avoid disastrous climate change and (iii) the ranking of contributions

[24]The variables are: *belief in climate change*, *concern with regards to climate change*, *trust on foreigners* and *frequency of travel abroad*.

of other participants.

At this point, participants do not know the country names of each participant in this ranking, but they have information on participants' individual contributions and endowments. Participants do not see the average contribution of others in T3, but they have all the information they need to calculate that number. The average contribution of others is exactly the same in the two rounds of T2 and T3 for every participant, so that these treatments are comparable.[25]

We start examining T3 choices by looking at how contributions change from T2 to T3. Since the payoff structure is the same in these two treatments, change in contributions should reflect only the change in the type of information participants receive—instead of seeing the average contribution of others, participants see a ranking order of contributions.

Table 5 shows that average contribution as a percentage of endowment increases for participants of every country in our sample from T2 to T3. This means that the way information is presented to participants has an impact on their contribution—the ranking order increases contributions to climate change mitigation as compared to the average contribution of others. We call this the ranking effect.

Table 5: Average % of Endowment Contributed in T2 and T3 per country

Country	**% Endowment T2**	**% Endowment T3**
EU	55.87	58.21
	(25.06)	(25.14)
US	51.84	53.67
	(28.42)	(28.43)
RSA	66.80	67.27
	(23.52)	(24.23)
China	58.96	60.33
	(24.43)	(25.14)
India	65.58	66.06
	(28.99)	(28.59)

Standard errors in parentheses.
All differences are statistically significant.

Combining Tables 2 and 5, we now can examine the evolution of contributions, per country, from T1 to T3. Participants of developed countries decrease, on average, contributions from T1 to T2, and increase contributions from T2 to T3, going back to levels close to their initial contribution in T1. Participants of developing countries, on the other hand, constantly increase contributions from T1 to T2 to T3.

To understand the ranking effect and how it changes participants' contributions, we run the following regression,

[25]Available choices, payoff structure and threshold level are all the same. The only difference between treatments 2 and 3 is the new information about the ranking order.

$$cont_{it} = \alpha + \beta_1 \cdot payoff_{it} + \beta_2 \cdot threshold_{it} + \beta_3 \cdot firstcont_{it} + \beta_4 \cdot lastcont_{it} + \epsilon_{it} \quad (2)$$

where $cont_{it}$ is the size of the contribution as a percentage of endowment of participant i at round t, *payoff* is the payoff participant i receives for her choice, *threshold* is a binary variable that receives value 1 if the threshold is met, *firstcont* is the size in percentage of endowment of the first ranking contribution, and *lastcont* is the size of the last ranking contribution.[26]

Table 6: Ranking Effect: Linear Regression on % of Endowment Contributed (T3)

Country	Payoff	Threshold	First Cont.	Last Cont.
EU	-0.059	0.462	0.239	0.397
	(0.0004)	(0.0049)	(0.0139)	(0.0111)
US	-0.042	0.404	0.310	0.194
	(0.0002)	(0.0046)	(0.0112)	(0.0093)
RSA	-0.010	0.622	0.119	0.123
	(0.0011)	(0.0075)	(0.0187)	(0.0223)
China	-0.086	0.599	0.115	0.146
	(0.0007)	(0.0056)	(0.0142)	(0.0182)
India	-0.128	0.724	0.162	0.294
	(0.0011)	(0.0060)	(0.0153)	(0.0232)

Robust standard errors in parentheses.
All coefficients are statistically significant at 1%.
Observations (R^2): EU - 3,084 (0.88), US - 2,942 (0.89), South Africa - 2,152 (0.81), China - 3,068 (0.83) and India - 3,080 (0.83).

Table 6 shows the results for participants from each country. We see that both first and last ranking contributions have a positive effect on participants' contribution. For example, an increase of 1 percentage point in the last ranking contribution increases EU participants' contribution by approximately 0.24 percentage points; this effect is even larger for the first ranking contribution, 0.4 percentage points.

The effect of the first ranking contribution is larger for participants from developed countries. A possible interpretation for this is that these countries usually take a leadership role in climate change negotiation, so participants from developed countries might pay more attention to what the first ranking contribution is doing as compared to participants from developing countries.

The situation is less clear-cut for the effect of the last ranking contribution. Participants from the EU and India have the largest coefficient here, which indicates that the last ranking position influences more participants from these two countries. They are followed by the US, China and South Africa. Since

[26]We also run this regression with round fixed effects, and with two controls, age and gender. Results remain the same.

this result is not correlated to other variables linked to climate change concern or knowledge, it seems that this might be an intrinsic feature of these participants—that is, the effect the contribution of the last position has on them is not related to the specifics of the problem their are responding to.

These regression results enable us to identify two components of the ranking effect: (i) a follow the leader component by which participants increase contributions as the first ranking contribution increases; and (ii) a shame component, which increases contributions as the last ranking contribution increases.

We now estimate how often participants choose a specific place in the given ranking order. Table 7 presents our results. Note that 'first place' in the ranking is defined as the largest contribution as a percentage of endowment by a participant, whereas 'last place' is the smallest contribution as a percentage of endowment.

Participants from developing countries choose to be in the last place of the contribution ranking less often than participants from developed countries. Participants from the US and the EU choose to be in the last place on approximately 14% and 7% of times, respectively. This result suggests that the shame component is larger among developing countries.

Table 7: Frequency of Place Chosen in the Ranking (T3)

Country	First Place	Middle	Last Place
EU	21.0%	71.6%	7.4%
US	29.8%	55.8%	14.4%
RSA	28.9%	66.8%	4.3%
China	17.5%	76.0%	6.5%
India	32.3%	61.7%	6.0%

When it comes to take the lead of climate change mitigation contributions, the results are mixed. India takes the lead more often—in 32% of times—followed by the US, South Africa, the EU and China. This result indicates that participants from developing countries are willing to lead climate change contributions as much as participants from developed countries.

4.3.2 With Country Names

In the last treatment of our experiment, we repeat T3, but now participants are able to see the name of each country in the ranking. The question we answer with this treatment is whether country identity changes participants' contribution to climate change mitigation.

As Table 19 in Appendix B shows, contributions do not change much from T3 to T4. Apart from participants from South Africa, who decrease contributions by 0.74 percentage points, participants increase contributions when they see the identity of countries. Participants from the EU increase their average contribution by 1.55 percentage points, followed by the US, 0.85, China, 0.55, and India, 0.05. The frequency of places chosen in the ranking order and the

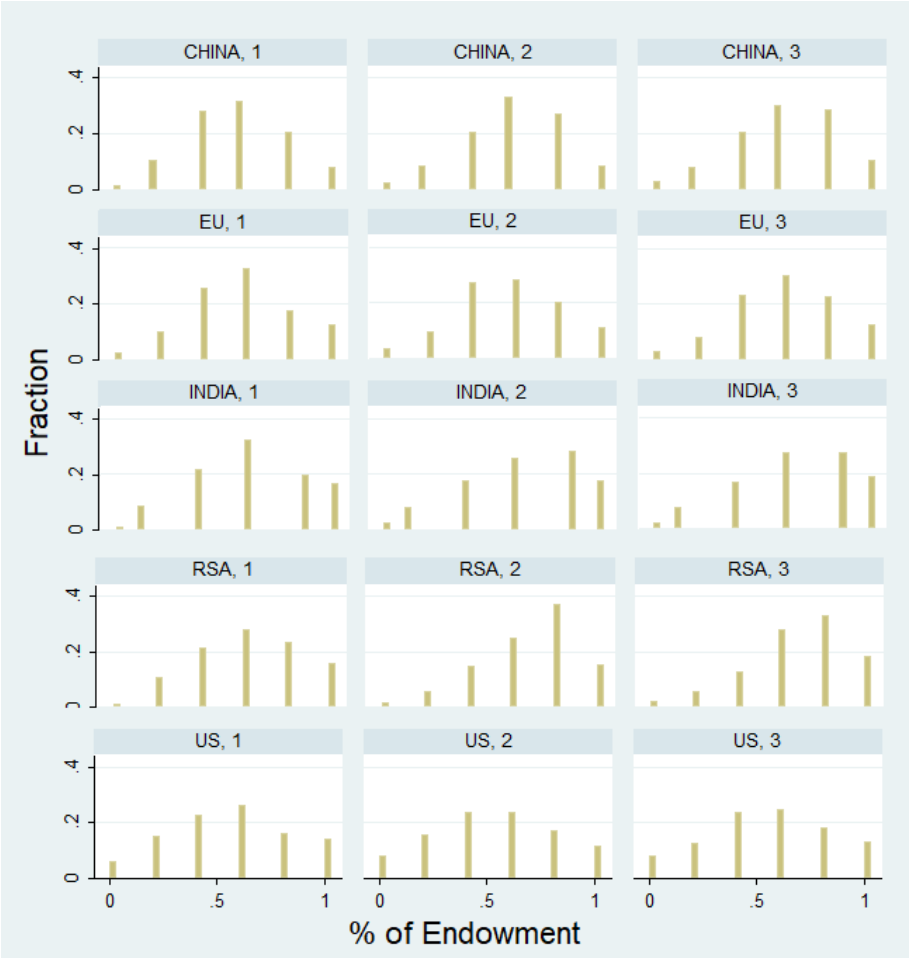
effect of the first and last places on participants' contributions do not change much either from T3 to T4.[27]

These results indicate that the identity of countries do not change participants' contribution to climate change mitigation. Information on the amount contributed and endowment, payoff and threshold happens to be more important than the name of each country.

4.4 Discussion

The results we present in this empirical analysis show that information about the average contribution of other participants and the ranking order do change participants' contributions to climate change mitigation. Depending of the relative size between average of others and initial contribution, participants can free ride or increase contributions. Similarly, information about the ranking order indicates that there is both a follow the leader and a shame effects, which might increase contributions overall. Interestingly, the identity of each contributor does not change much contributions on average.

Figure 2: Types of Participants (% of Endowment in T1, T2 and T3)



[27] See Tables 19, 20 and 21 in Appendix B for the coefficient values.

To finish this section, we return to the question we posed at section 4.1.2. Is the information given in each treatment capable of changing participant's types? We are interested in whether our treatments can induce participants to change from purely rational to collective problem solvers.

Figure 2 presents the evolution of the proportion of types of participants for each country, from T1 to T3. We see a clear divide between the behaviour of participants from developing countries and developed countries. In general terms, participants from developed countries become more collective problem solvers as the experiment progresses. Specially for South Africa and India, there is a clear increase on the right tale of the distribution from T1 to T3. This suggests that the perceived behaviour of others is enough to change the overall norm that these participants are following.

Participants from developed countries are less open to change their types. There is a slightly increase in the proportion of collective problem solvers for the EU, but no significant change for the US. In fact, the proportion of purely rational American participants slightly increases from T1 to T3. Hence, contrary to participants from developing countries, it appears that behaviour norms linked to climate change mitigation are more difficult to change in participants from developed countries.

5 Concluding Remarks

Our experiment examines how the supposed behaviour of others affects participants' preferences towards climate change mitigation. We decompose these preferences into a purely rational component—total payoffs—and a collective component—threshold and information on contribution of others. We find that the behaviour of others can change a participant's willingness to contribute to climate change. This change is a function of both the information received by a participant and her individual characteristics.

We identify several behavioural effects in response to the information given to participants in our treatments: (i) free ride and follow the lead of others—participants from developed countries free ride on the average of others, whereas participants from developing countries follow the lead of the majority; (ii) ranking effect—as compared to information on the average of others, a ranking order increases participant's contributions; (iii) follow the leader and shame effects—both the first ranking contribution and the last one increase participants' contributions to climate change, although the shame effect is stronger among participants from developing countries. We do not find an effect of country names on contributions to climate change mitigation.

From an international negotiation perspective, our results suggest that effects such as follow the lead of the majority and the shame effect can be used to foster global contributions to climate change. Information on the contribution of other countries might push top-emitter countries to increase contributions. As our third treatment shows, this information would be more effective if it comes in the form of a ranking order, where contributions and endowments are shown. Interestingly, the identity of the countries in this ranking appears to be less important than their contributions and the amount available to contribute.

As a caveat, it is important to mention that the behaviour of participants in our experiment does not automatically translate into the behaviour of countries in an international negotiation. Moreover, even if that was the case, an international negotiation does not have the controlled environment we have in our experiment. However, our study sheds light on the preferences of the general population of these five countries towards climate change mitigation, and indicates how their leaders would behave if they align with these preferences.

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Appendix A

Examples:

Figure 3: Payoff Structure - Example shown to South African participants (Introduction)

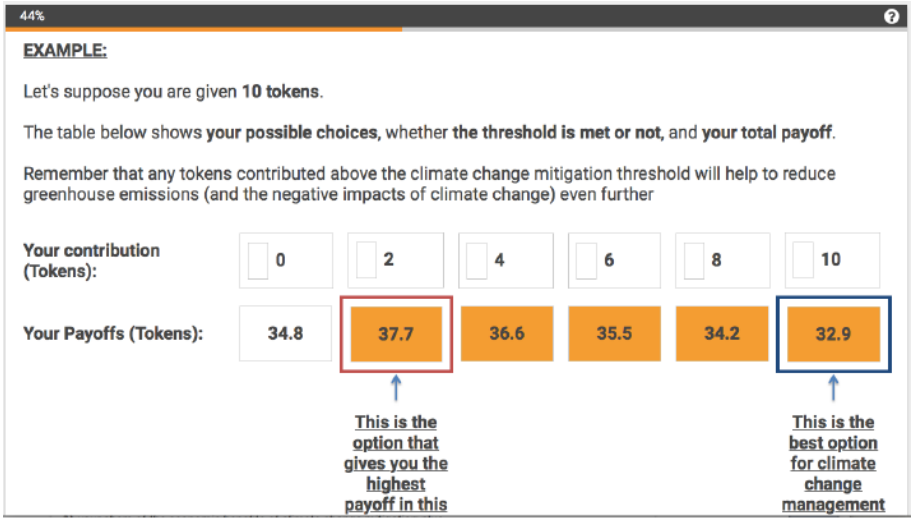
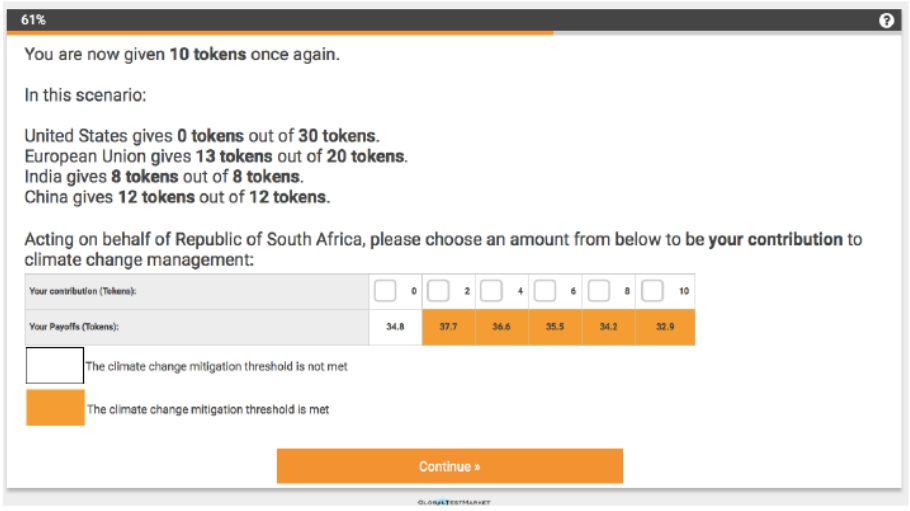


Figure 4: Example of Treatment 4 - South Africa



Descriptive Statistics:

Table 8: Descriptive Statistics - Gender

	EU	US	China	South Africa	India
Male Population	48.83%	49.48%	51.33%	49.33%	51.98%
Male Sample	49.40%	47.10%	50.10%	48.60%	54.40%
Female Population	51.17%	50.52%	48.67%	51.67%	48.02%
Female Sample	50.60%	52.60%	49.90%	51.20%	45.50%
'I choose not to declare'	0.10%	0.30%	0.00%	0.20%	0.10%

Source: World Bank staff estimates based on age/sex distributions of United Nations Population Division's World Population Prospects: 2019 Revision. Values are for 2017.

Table 9: Descriptive Statistics - Age

	EU	US	China	South Africa	India
15-24 Pop.	10.39%	12.91%	11.48%	16.80%	17.51%
18-24 Sample	2.90%	4.70%	15.30%	11.20%	21.40%
25-54 Pop.	40.54%	38.92%	46.81%	42.37%	41.56%
25-44 Sample	47.90%	42.70%	68.40%	57.50%	55.10%
55-64 Pop.	13.52%	12.86%	12.08%	6.80%	7.91%
45-64 Sample	35.90%	35.40%	15.90%	24.30%	18.80%
65+ Pop.	20.50%	16.85%	12.34%	6.09%	6.72%
65+ Sample	13.40%	17.20%	0.40%	7.10%	4.80%

Source: The World Fact Book - CIA (2020).

Table 10: Descriptive Statistics - USA Ethnic Groups

US Ethnic Group	%
White Pop.	60.30%
White Sample	73.40%
African American Pop.	13.40%
African American Sample	4.50%
Asian Pop.	5.90%
Asian Sample	11.80%
Hispanic Pop.	18.50%
Hispanic Sample	7.00%
Other Pop.	4.30%
Other Sample	2.20%
'I choose not to declare'	1.00%

Source: 2019 U.S. Census Bureau Estimates.

Table 11: Descriptive Statistics - South Africa Ethnic Groups

RSA Ethnic Group	%
Black African Pop.	80.20%
Black African Sample	40.10%
Coloured Pop.	8.80%
Coloured Sample	10.50%
Indian or Asian Pop.	2.50%
Indian or Asian Sample	4.90%
White Pop.	8.40%
White Sample	42.80%
Other Pop.	0.50%
Other Sample	0.10%
'I choose not to declare'	1.50%

Source: 2011 South African Census.

Table 12: Descriptive Statistics - US Party Affiliation

Party	%
Democrats Pop.	31.00%
Democrats Sample	50.40%
Republicans Pop.	25.00%
Republicans Sample	38.60%
Other Pop.	3.00%
Other Sample	0.40%
Independent Pop.	41.00%
Independent Sample	10.60%

Source: Gallup Historical Party Affiliation (2020).

Table 13: Descriptive Statistics - India Castes

Castes	%
General Caste Pop.	28.80%
General Caste Sample	76.20%
Scheduled Caste Pop.	16.60%
Scheduled Caste Sample	4.20%
Scheduled Tribe Pop.	8.60%
Scheduled Tribe Sample	1.00%
Other Backward Castes Pop.	41.00%
Other Backward Castes Sample	12.70%
Other Pop.	5.00%
Other Sample	2.50%
'I choose not to declare'	3.40%

Source: 2011 Census of India.

Table 14: Descriptive Statistics - How would you rate your knowledge of climate change?

	EU	US	China	South Africa	India
I don't know anything	3.30%	5.40%	2.60%	3.40%	4.20%
I know something	71.30%	67.90%	77.10%	71.30%	65.00%
I know a lot	25.40%	26.70%	20.30%	25.30%	30.80%

Table 15: Descriptive Statistics - In general, how concerned are you about climate change?

	EU	**US**	**China**	**South Africa**	**India**
Very Concerned	22.60%	29.40%	30.50%	34.80%	49.70%
Concerned	57.70%	41.70%	56.90%	50.70%	41.20%
Neutral	13.90%	15.10%	12.10%	11.00%	8.60%
Not Concerned	4.30%	7.90%	0.40%	2.90%	0.30%
Not Concerned at all	1.50%	6.00%	0.10%	0.70%	0.20%

Table 16: Descriptive Statistics - Which of the following statements do you think best describes the reality of climate change?

	EU	**US**	**China**	**South Africa**	**India**
CC is not occurring	0.60%	4.50%	1.60%	0.40%	2.50%
CC is occurring, but not as a result of human activities	8.20%	13.80%	9.60%	5.10%	10.50%
CC is occurring, and a major cause is human activities such as the burning of fossil fuels	69.60%	61.50%	72.90%	78.20%	77.00%
There is a lot of disagreement among scientists about whether CC is occurring and about its potential causes	20.00%	17.20%	14.70%	14.50%	7.90%
I do not know	1.60%	3.00%	1.10%	1.80%	2.10%

Appendix B

Table 17: Determinants of Unconditional Contributions (T1) – OLS Regression

Characteristics	**on % Endowment**
Strongly Agree (common goal)	0.0990
	(0.0773)
Agree	0.0663
	(0.0773)
Neutral	0.0139
	(0.0782)
Disagree	0.0320
	(0.0928)
CC occurring but not human	0.00306
	(0.0231)
CC occurring and humans major cause	0.0330
	(0.0220)
Lots of disagreement about CC causes	0.0150
	(0.0228)
I don't know	-0.0242
	(0.0325)
Very Concerned (climate change)	0.354***
	(0.0282)
Concerned	0.304***
	(0.0279)
Neutral	0.253***
	(0.0284)
Not Concerned	0.113***
	(0.0318)
I know something (climate change)	-0.0211
	(0.0165)
I know a lot	0.000198
	(0.0175)
At least once (travel abroad)	-0.0154
	(0.00975)
More than once	0.0142
	(0.00895)
Many times	0.00183
	(0.00889)
Strongly Agree (trust foreigners)	0.0495**
	(0.0212)
Agree	0.0289
	(0.0184)
Neutral	0.0154
	(0.0179)
Diagree	0.00651
	(0.0190)
Strongly Agree (gvt intervene international prob)	0.0401*
	(0.0241)
Agree	0.0203
	(0.0236)
Neutral	-0.0152
	(0.0241)
Disagree	-0.0222
	(0.0261)
Constant	0.155*
	(0.0824)
Observations	7,163
R-squared	0.124

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 18: Determinants of an Increase in Contributions (from T1 to T2) – OLS Regression

Characteristics	**on Increase in Contr.**
CC occurring but not human	0.0329
	(0.0266)
CC occurring and humans major cause	0.0708***
	(0.0252)
Lots of disagreement about CC causes	0.0611**
	(0.0264)
I don't know	0.0652*
	(0.0373)
Very Concerned (climate change)	0.135***
	(0.0252)
Concerned	0.148***
	(0.0246)
Neutral	0.142***
	(0.0259)
Not Concerned	0.102***
	(0.0307)
At least once (travel abroad)	-0.0268**
	(0.0126)
More than once	-0.0504***
	(0.0116)
Many times	-0.0573***
	(0.0115)
Strongly Agree (trust foreigners)	-0.0377
	(0.0247)
Agree	-0.0157
	(0.0218)
Neutral	0.00683
	(0.0213)
Disagree	0.0195
	(0.0233)
Constant	0.130***
	(0.0339)
Observations	14,326
R-squared	0.008

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 19: Average % of Endowment Contributed in T3 and T4 per country

Country	% Endowment T3	% Endowment T4
EU	58.21	59.76
	(25.14)	(25.89)
US	53.67	54.52
	(28.43)	(29.08)
RSA	67.27	66.53
	(24.23)	(25.51)
China	60.33	60.88
	(25.14)	(25.46)
India	66.06	66.11
	(28.59)	(29.06)

Standard errors in parentheses.

Table 20: Ranking Effect: Linear Regression on % of Endowment Contributed (T4)

Country	Payoff	Threshold	First Cont.	Last Cont.
EU	-0.059	0.468	0.243	0.404
	(0.0004)	(0.0051)	(0.0143)	(0.0111)
US	-0.042	0.407	0.311	0.190
	(0.0002)	(0.0046)	(0.0109)	(0.0094)
RSA	-0.102	0.635	0.140	0.153
	(0.0011)	(0.0076)	(0.0186)	(0.0228)
China	-0.086	0.5992	0.113	0.135
	(0.0008)	(0.0056)	(0.0142)	(0.0186)
India	-0.129	0.742	0.150	0.332
	(0.0011)	(0.0062)	(0.0159)	(0.0232)

Robust standard errors in parentheses.
All coefficients are statistically significant at 1%.
Observations (R^2): EU - 3,084 (0.89), US - 2,942 (0.89), South Africa - 2,152 (0.82), China - 3,068 (0.83) and India - 3,080 (0.84).

Table 21: Frequency of Place Chosen in the Ranking (T4)

Country	First Place	Middle	Last Place
EU	21.6%	70.3%	8.1%
US	30.0%	55.7%	14.3%
RSA	27.9%	67.0%	5.1%
China	18.4%	74.8%	6.8%
India	32.0%	61.4%	6.6%