"Income Heterogeneity and Communication in Global Public Goods"

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Abstract

The stabilization of the world's climate is a perfect case of a collective action problem that—because the efforts by an individual country have little effect—requires coordination among countries in order to attain desirable outcomes. Experimental evidence suggests that one way of attaining such coordination is by allowing for interaction and negotiation among heterogeneous agents and/or groups of such agents. In this paper we test experimentally the potential gains of interaction among heterogeneous agents in the presence of a collective action problem such as climate change negotiations. This research has direct implication for advising policy makers and country officials at climate negotiations in order to achieve an international climate change agreement. Addressing affirmatively this research question should advice officials about the convenience to act together, or in country-blocks, when negotiating green-house gas (GHG) emission reductions for the next international climate change agreement.

1. Introduction

Protection of the global climate is a perfect case of the well-documented collective action problem in the field of economics. Individual country emissions of greenhouse gases (GHG) have significant implications for a much broader group, such as the global community of nations. Furthermore, when contrasting aggregate cost and benefits, the aggregate benefit of reducing GHG emissions largely exceeds its aggregate costs. Because of this, it is necessary for nations to cooperate to cope with climate change – one nation acting alone cannot have much effect. However, the lack of an institution that can enforce contributions to reductions of GHG (like a world government) makes stabilization of the world's climate rely solely in voluntary efforts for its provision.

Accordingly, at recent negotiations in the context of UN Framework Conferences for Climate Change (UNFCCC) most countries have pledged reductions in emissions of GHG that seek to mitigate climate change. At these conferences, a few key players negotiate the bulk of GHG emission reductions that will be undertaken to mitigate climate change. These players are either countries acting alone (such as US and China) or countries acting in blocks (such as EU, AOSIS, Middle East, Africa and the so called BRICS economies).[1] Thus, to respond to the 'big powers' in climate negotiations some developing nations have grouped together to have more leverage in climate negotiations.

There are many features that distinguish these players (countries or groups of countries acting in a block) but a common trait of all of them is that they want to minimize the potential damage from climate change at the least possible cost. Some of these players are industrialized economies, whereas others are developing nations. Although developing nations are thought to

[1] AOSIS = Alliance of Small Island States; BRICS = Brazil, Russia, India, China and South Africa. http://unfccc.int/parties_and_observers/parties/negotiating_groups/items/2714.php

be the ones that will suffer the most from a warmer globe, by acting alone they can do little to reduce global emissions. However, it is on their best interest to achieve larger (and more efficient) global GHG reductions.

Given the large spectrum of the players involved in these negotiations, in this research we focus on the heterogeneity of the agents involved in the negotiations on the (necessary) reductions of GHG in order to mitigate climate change. On the other hand, interaction (and communication) is more likely to take place at these negotiations when it involves countries with common interests and similar characteristics. That is, countries that (a) share a common historic background and similar political institutions, (b) have similar levels of economic development (per-capita GDP), and, (c) are expected to face similar effects from climate change.

As a consequence, we treat the problematic described above as a collective action problem and we focus on the gains from interaction (and communication) among groups of similar features. Therefore, in this research we aim to test the potential gains of interactions (and communication) among heterogeneous agents when in the presence of collective action problems, such as climate change negotiations. Thereby, by means of computer lab experiments, this research tests the gains from interaction within groups as well as the gains from having group-representatives that can interact and communicate among different groups.

Hence, in this paper we address the following research questions: *(1) Can communication within groups of agents increase provision in collective action problems? (2) Can communication among group-representatives increase provision?* Additionally, there is a broad set of questions that can be derived from the ones stated above, such as: *who benefits most from group and group-representative communication? Do disadvantages groups benefit from it? Does the*

method of choosing a group-representative increase provision as compared to a representative that is arbitrarily imposed? What if groups are not fully homogeneous?

2. Overview of the related literature

Collective action problems have been largely studied in both field and lab experiments in the context of contributions to public goods experiments as well as extraction of common property resources. The effects of communication are quite robust across these experiments: communication among agents increases cooperation in collective action problems [Ostrom, 1992; Ostrom, Walker and Gardner, 1992].

On the other hand, the effects of heterogeneity are mixed and it seems to ultimately depend on the shape of the underlying benefit function. For example, in the context of contributions to public goods, experimental evidence shows that heterogeneity decreases cooperation when the agent's payoff function is assumed linear whereas heterogeneity increases cooperation when the agent's payoff function is assumed non-linear [Chan, Mestelman, Moir and Muller, 1999]. When tested together, both communication and heterogeneity, the positive effect of increased cooperation from communication seems to prevail (Bochet, Page and Putterman, 2006).

In this research we test both interaction (communication) and heterogeneity in a public good lab experiment. However, unlike the previous literature, we will focus on communication and agent-heterogeneity in the context of a global public good. Therefore, in addition to allowing for communication among heterogeneous agents (as in the current literature), in this experiment we test a specific two-level communication structure; at the first level

communication occurs *within groups of homogeneous agents*, whereas at the second level communication occurs *between heterogeneous groups* via group-representatives. The reason underlying this two-level communication structure is to capture the fact that, in real world collective action problems, communication (and coordination) tends to occur mostly within groups with common interests and characteristics; and, when dealing with other different groups, these groups tend to delegate their communication responsibilities to a representative.2 More details on the structure of the experimental design can be found in the appendix at the end of this document.

3. **Experimental Design**

Computer-based experiments were conducted at the Experimental Lab of the Department of Agricultural and Resource Economics of the University of Maryland, College Park (Maryland, USA).[3] We recruit undergraduate students to participate as experimental subjects. These individuals faced the same situation and incentives as in the collective action situation outlined in the previous section. Participants were paid in cash according to their performance in the experiment. The research questions were thus tested in the Lab in a computer-based experiment by means of using the experimental software Ztree 3.1 (Fischbacher 2007).

The experiment consists of four treatments that allow us to test experimentally the research questions stated above. In all treatments, individuals are grouped together in groups of 9 and they participate in a public goods game with linear payoffs. The appendix at the end of this document illustrates individual types as well as the treatments detailed below. Individuals were assigned to one of three types: A, B and C. Individuals type A and B are given a low

[2] Indeed, Buchner & Carraro underline that the bottom-up approach of climate negotiations to reduce GHG emissions has led to formation of *climate blocs* (or regional agreements) in which each country determines its contribution to reduce GHG emissions.

[3] The Experimental Lab at the Department of Agricultural and Resource Economics at the University of Maryland is specially designed to run this kind of experiments. Experimental subjects can privately work on any of the 24 computer terminals that are inter-connected in real time through the main server.

endowment whereas individuals type C are given a high endowment. As in most public good experiments, this endowment had to be allocated between a private good (yielding earnings for the individual only) and a public good (yielding earning for everyone in the same group). In addition, type A individuals face low benefits from the public good whereas type B individuals face high benefits from the public good. Individuals type C also face high benefits from the public good. The treatments are as follows: (i) no communication; (ii) communication across all agents; (iii) within-group communication only; (iv) communication between groups via group-representatives (arbitrarily assigned).

We look at subjects' contributions in an experiment of voluntary contributions to a public good that, in some treatments, allows for full or partial communication among participants. We have data on contributions and earnings for each of the four treatments explained above. As explained below, analysis of contributions and earnings will allow us to answer the research questions stated above.

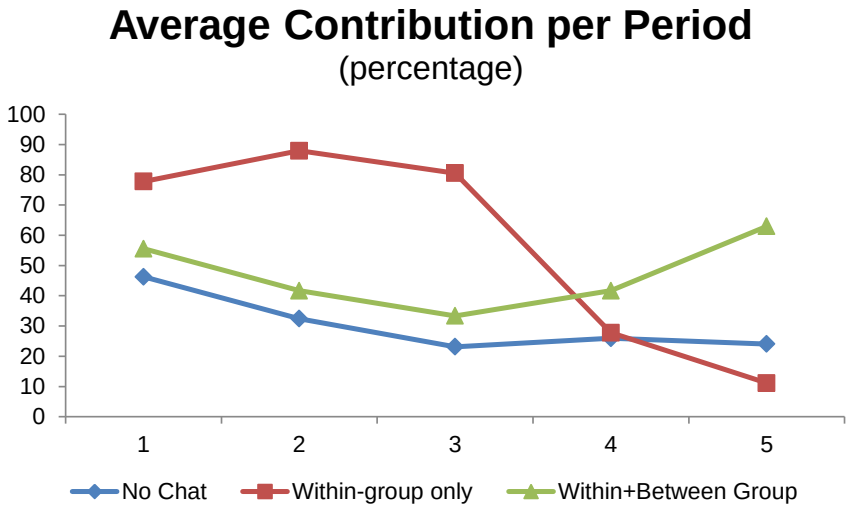
4. Preliminary Results

The main contribution of this research to the empirical experimental literature is the introduction of heterogeneity in experiments that test the collective action problem that allow for communication and coordination among agents. Communications is not only allowed at the aggregate level, but also at the group-level (only) as well as communication at the group-level and between group-representatives.[4]

[4] Unlike the previous experimental literature, we are also considering testing whether the introduction a democratic rule has any significant effect as compared to an exogenously appointed group-leader.

a. Effects on contributions to the public good

The main treatments have been tested in a pilot experiment using nine students. Preliminary results based on this pilot experiment are presented below in the graph below. The graph shows average contribution across all subjects as percentage of their endowment. The blue line shows contributions for the treatment (i) in which no communication was allowed. The red line shows contributions for the treatment (ii) in which communication was allowed only within same-type groups. Finally, the green line shows contribution in the (iii) treatment in which communication was allowed within same-type groups as well as across groups of different types via an (arbitrarily assigned) group representative that communicated with other group representatives.



The graph shows that when allowing for communication within homogeneous groups (*within-group*, red line) individuals make larger contributions to the public good as compared to the situation with no communication (blue line). However, and contrary to previous literature [Angelowsky and Reuben, 2012], adding communication between heterogeneous groups (*within+between*, green line) to the previous situation reduces contributions to the public good to a level similar to the situation with no communication (blue line). Thus, contrasting these

findings to the current experimental literature, it seems that the heterogeneity effect prevails over the communication effect in the context of same-type group communication and communication across heterogeneous groups of different types.

Next, we use regression analysis to look at the effects of these treatments on subject's contributions as a percentage of their endowment. The regression estimates supports the findings from the graph above. Within group communication increases contributions whereas adding between-group communication brings contributions down to levels similar to the situation with no communication.

Dep Var: Contribution to PG (% of endowment W)

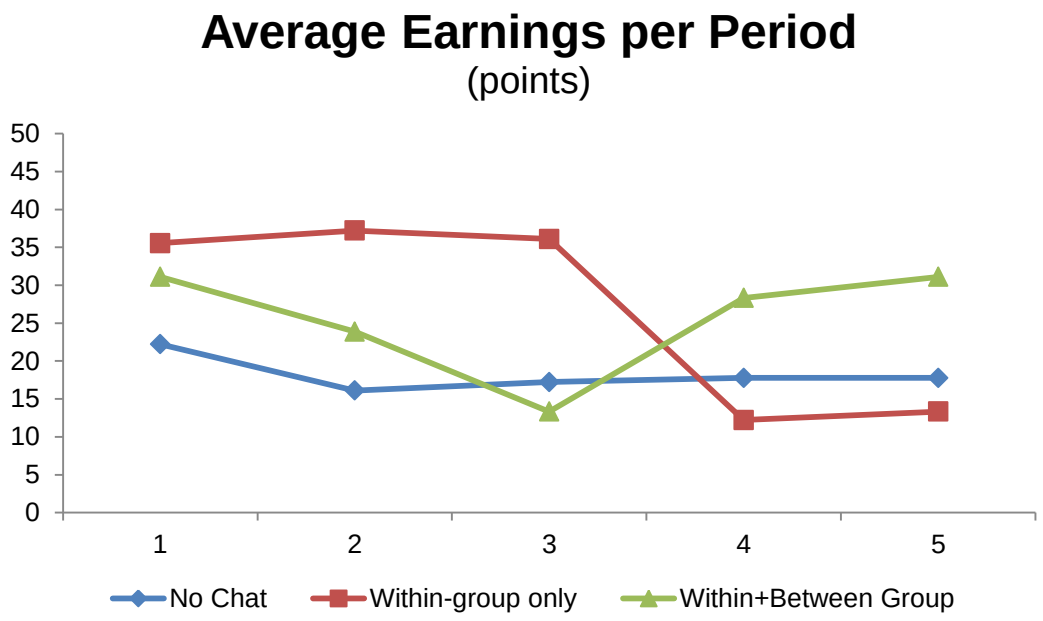
	(1)	(2)	(3)
Period	-0.0765+	-0.0765+	-0.0765+
	(0.0367)	(0.0367)	(0.0370)
Type-B	0.206		0.206
	(0.187)		(0.162)
Type-C	0.322		0.322*
	(0.186)		(0.138)
Within Group Comm.		0.267*	0.267+
		(0.106)	(0.120)
Between+Within		0.167	0.167
		(0.206)	(0.118)
Constant	0.502+	0.533**	0.357+
	(0.244)	(0.125)	(0.189)
Observations	135	135	135

Standard errors in parentheses
clustered at the Type-Treatment level
"+ p<0.1, * p<0.05, ** p<0.01, *** p<0.001"

Furthermore, Type-C individuals, those who have high endowments and present high benefits from the public good, make higher contributions to the public good than those Type-A individuals who have low endowment and low benefit from the public good (omitted category in the regression table)

b. Effects on earnings from the public good

Additionally, in this research we look at the average earnings of the different types under these treatments. Contrasting agent's earnings under each of the different treatments will allow us to gauge the optimality of the communication structure. Preliminary findings show that communication increases earnings whereas there seems to be no clear effect of any particular communication structure (within vs. between).



The table below confirms this observation. Both the parameter on Within Group Communication as well as Within+Between Communication turn positive and statistically

significant. However, there seems to be no statistically significant difference of the effect of the communication treatments on the subject's earnings.

Dep Var: Net Earnings from PG (Earnings - W)			
	(1)	(2)	(3)
Period	-2.407+	-2.407+	-2.407+
	(1.256)	(1.256)	(1.266)
Type-B	11.34*		11.34***
	(3.581)		(1.491)
Type-C	6.116+		6.116***
	(2.895)		(1.199)
Within Group Comm.		8.667+	8.667***
		(4.376)	(1.504)
Between+Within		7.333+	7.333***
		(3.366)	(1.037)
Constant	18.29**	18.78**	12.96**
	(4.107)	(4.258)	(3.588)
Observations	135	135	135

Standard errors in parentheses
clustered at the Type-Treatment level
"+ p<0.1, * p<0.05, ** p<0.01, *** p<0.001"

Furthermore, regression results show that, as expected, those who present high valuation from the public good are the ones that enjoy the highest earnings. However, even among those high valuation individuals, the ones that are given low endowment (type B individuals) are the ones that have the highest earnings.

5. Concluding Remarks

In this paper we test experimentally the potential gains of a specific structure of communication among heterogeneous agents in a social dilemma public good experiment. We believe that the communication structure studied here is relevant for the context of carbon emission reductions at UN climate negotiations. We believe that agents that are more similar are also more likely to engage on communication and interaction with each other. Because of this, we test whether allowing for communication within homogeneous individuals has a positive effect on contributions to a public good. We find preliminary evidence to support this hypothesis.

Furthermore, at a global level, we believe that heterogeneous agents can better communicate and interact if they reduce the number of parties. Thus, we impose a communication structure in which heterogeneous agents can communicate by means of a group-representative and test whether this communication structure has any effect on contributions to a public good. Preliminary results suggest that there is no difference in contributions (that is statistically significant) by introducing communication across groups via a group-representative.

Therefore, this preliminary evidence suggests that group communication would increase contributions to a global public good such as the preservation of the world's climate.

APPENDIX 1: Experimental Design

Experimental subjects will participate in a linear public goods game with payoff function:

$$\pi_i = \alpha x_i + \beta G$$

where x_i= consumption of private good, and G= consumption of public good (PG)

Each individual i is given and endowment ω_i that can assign either to consumption of private good (x_i) or contribute g_i to provision of a PG, such that $\omega_i = x_i + g_i$.

The total provision of PG G is given by the sum of contributions g_i across all individuals i: $G = \sum_i^N g_i$

The collective action problem emerges when it is individually optimal not to contribute to the public good but it is socially optimal to fully contribute to the PG. The following restriction on the parameter values guarantees that this structure represents the collective action problem: $< \alpha < N\beta$.

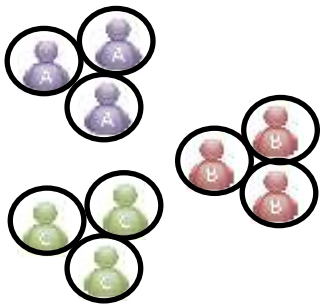
Agent heterogeneity is introduced by varying both the endowment and the preferences for public good. In this design we introduce endowment heterogeneity by assigning individuals with wither *high* or *low* endowment (ω_i^H or ω_i^L). Furthermore, we introduce preference heterogeneity by varying the parameter β that denotes the benefits from the public good (β_i^H or β_i^L). Therefore, we introduce heterogeneity by forming three different types of agents (A, B and C) as illustrated in the table below.

Agent Types

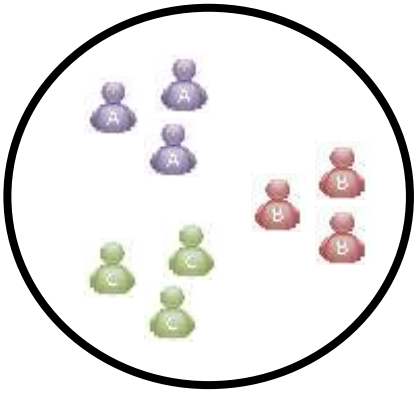
	Low endowment (ω_i^L)	High endowment (ω_i^H)
High benefit from PG (β^H)	**B**	**C**
Low benefit from PG (β^L)	**A**	

Treatments

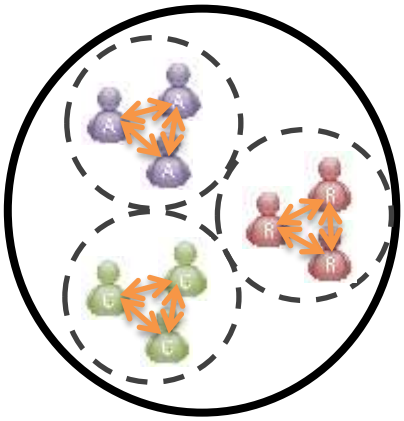
i. **No communication**



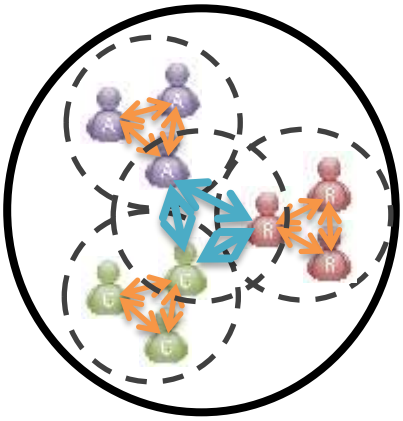
ii. **Communication among all agents**



iii. **Communication *within* same-type Group**



iv. **Communication *within* group + *between* groups via group-representative**



Rules of the PG game

- Individuals know parameters of all types: Endowment (ω) and preference for public good (β).
- 10 rounds of voluntary contributions to an intergroup PG

Stages of the PG game

- Individuals privately learn their type: weather they are type A, B or C.
- Chat for 1 minute before each round (when treatment allows for it)
- Privately make contributions to PG.
- After all had made their contribution, they privately learn the total contribution to the PG, their individual earnings, and the average contribution and earnings of each type.

Experiment Screenshots

Results of round 1

- Your Contribution = **2**
- Total Contribution = **28**
- **Your Earnings = 32.4**

Average across types (you are type 3)

	Contributions	Earnings
Type 1	1.7	13.5
Type 2	1.7	24.7
Type 3	6.0	28.4

OK

Instructions to participants

WELCOME

Today you will be participating in an experiment on economic decision making. You are not supposed to communicate with each other during the experiment. If you have doubts, please raise your hand. There will be three parts of this experiment. We will explain below the rules for the first part and, later on, we will explain the rules for part two and three.

During the experiment you will want to make as many *points* as possible –think of it as if you want to make as much money as possible**.** You all will play five rounds of the game described below. During each round, each participant has to decide on how much to contribute to a *project* out of his/her endowment of ω points. Everyone benefits from the total contribution to the *project* across all participants. Your earnings will be determined as follows:

$$Earnings = \omega - x_i + \beta \sum x_i$$

where $\boldsymbol{x_i}$ is **your contribution** to the project and $\sum \boldsymbol{x_i}$ is the **sum of contributions** across all participants.

Additionally, you will be randomly assigned to one of three types; where each type is characterized by the parameters in the table below.

Type	$\boldsymbol{\omega}$	$\boldsymbol{\beta}$
1	4	.4
2	4	.8
3	12	.8