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Understanding Cooperative Behavior against Climate Change through a Public - Goods Game

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ABSTRACT

Atmospheric carbon-dioxide (CO_2) emissions are increasing at an alarming rate. If this increase remains unchecked, then it would lead to disastrous consequences like temperature change, sea-level rise, and diseases world over. Therefore, it is important to study how global cooperation emerges against climate rechange. A public-goods game, a popular economic device, could be used to study cooperation behavior against climate change. In this paper, we study the emergence of global cooperation against climate change using a modified form of a public-goods game. In this game, four players from different world economies (based upon wealth) decide to invest an amount into a public fund for averting climate change. The invested amounts are multiplied by economy-specific return-on-investment factors and the total return-on-investment is then divided equally among all players. Players' payoffs are also influenced by probabilistic losses due to climate change, where the magnitude of the loss and its probability are a function of investments made by all players to the public fund. In future, we plan to use this game to study people's cooperation behavior against climate change.

Keywords: Climate change, cooperators, defectors, free riders, public-goods game, social dilemma.

1. INTRODUCTION

Climate change is a global phenomenon that has been affecting all world nations. It is primarily caused by rising carbon-dioxide emissions and concentrations [20]. According to [20], carbon-dioxide concentration increase could likely cause catastrophic consequences sea-level rise, increase in temperature and decline in food production. It is well known that climate change is a global phenomenon that affects us all and thus it needs to be addressed immediately by all nations together.

Several climate negotiations, such as the United Nations Framework Convention on Climate Change (UNFCCC), and international environmental agreements like Kyoto Protocol, which are used as mechanisms for inducing cooperation, have failed [18]. Given the current lack of success of global agreements against climate change, it is important to investigate how cooperation emerges as a result of probabilistic losses due to climate change as well as due to a greater transparency on carbon-dioxide emission reductions achieved by players. Public-goods game is an n-player game where different players play a repeated game by contributing money to a public fund in each round. In the basic game, players secretly choose how many of their private tokens (representing money) to be put into a public pot. The tokens in this pot are multiplied by a factor (greater than one and less than the number of players, N) and this "public good" payoff is evenly divided among players. Each player also keeps the tokens they did not contribute. Depending on the experiment's design, those who contribute below average or nothing to the public pot are called *defectors* or *free riders* as opposed to the contributors or above average contributors, who are called *cooperators*. In this paper, we adapt the conventional public-goods game to climate-change problem in order to study global cooperation behavior against climate change. The public-goods game framed for climate change takes into account four different world economies as four players. The game is played between four world economies because in the real-world there exist disparities in income, losses due to climate change and carbon-dioxide emissions between world nations. The objective in the game for a player is to decide how much of her endowment to contribute to a public fund to avert climate change. The pressure to contribute to the public fund is provided by two factors: The availability of information to players about everyone's monetary contributions to the public fund; and, the probabilistic losses due to climate change that are a function of players' contributions to the public fund from the start of the game. First, we discuss literature on using public-goods game for climate change, then we describe the model used for developing the game. Finally, we suggest values to different parameters in the model and emphasize the utility of our game, called public-climate game, in investigating people's cooperation behavior against climate change.

2. BACKGROUND

Literature reveals the effects of contexts in public-goods games. For example, authors have verified that contexts added to experimental instructions alter experimental results in such games [8], [12], [22]. In 2004, a repeated public goods-game was conducted with Israeli pilots and undergraduate students which showed that altruistic giving is increases significantly. This game was called the Wall Street Game by half the participants and the Community Game by the other half. It was observed that cooperation in the Wall Street Game was remarkably less [12]. Burnham in his paper, shuffled the two terms partner and opponent in a two-person trust game. It was observed that context has a notable effect on the results as use of the term partner is trustworthy than opponents [22].

Furthermore, in a study conducted it was observed that framing enables subjects to draw their own subjective perceptions about climate mitigation when deciding on their contribution strategy [4]. They find that subjects had clear attitudes about climate change. About 77% of subjects felt that firms should definitely be obligated to meet emission reduction targets, whereas only 15% felt that households should definitely be obligated to meet emission reduction targets. Thus, climate change context and proper framing influences cooperation behavior on climate change.

Furthermore, heterogeneity has always remained a key feature of climate talks. The effect of income heterogeneity on contributions has been examined by varying subjects' endowments. It has been found that for some endowment asymmetry increases cooperation [6], [7], [23] while for others it diminishes cooperation [24], [25]. Heterogeneity has also been illustrated by varying players' impacts on both the public and private accounts. Subjects were assigned different rates of return for their private accounts and found that the greater the return to the private good, and the higher the opportunity cost of public contribution, the lower the cooperation rates [16]. In a research, heterogeneity has been examined by varying the marginal per capita return (MPCR) within groups [26]. They found that high-MPCR players contribute more to public good relative to low-MPCR players. Thus, heterogeneity is a desirable construct in a public-goods game for climate change. It is more so because there is real-world heterogeneity present among global players in the real world. However, a majority of public good games that are framed in a climate change context do not incorporate within-group heterogeneity into the framing. In this paper, we include within-group heterogeneity by including different MPCRs and private return-on-investments for different players in the public-climate game.

The probability of losses due to climate change is also an important factor for cooperation behavior against climate change. Researchers, who studied the trade-off between mitigation and adaptation, extended a one-shot public-goods game by introduction of a term that represents the probability of disaster from climate change. The probability of disaster, a function of investments made to the public fund, is varied across treatments. Due to this variation, the contribution levels to the public fund were lower. However, some authors have failed to find an effect of probability of losses on cooperation behavior against climate change [11]. For example, it was found that there is no notable difference in the cooperation levels when probability of disaster is varied [15].

Furthermore, it has been shown that as amount of information about other's actions in a game increase, the cooperation

behavior among player also increases [27]. Thus, information availability has an influence on people's decision making in games. In this paper, we propose to include information availability as one of the manipulated factors in our public-climate game.

3. METHODOLOGY

In this paper, we develop a modified form of public-goods game called public-climate game. We would like to use this game to study the effects of probabilistic losses due to climate change as well as the amount of information available to different players on cooperation behavior against climate change. In this game, four players (from four different world economies) repeatedly decide how much money to put in public fund to avert climate change from occurring. Players are punished with losses if climate change occurs, where the occurrence of climate change is a probabilistic event. Here, the probability of losses on players due to climate change increases with increasing non-investing decisions of players. As per this model, if players invest in the public fund, then climate change is less likely to occur and the players will suffer less as compared to the situation when investments to the public fund are scarce. The game is played in a social dilemma framework, where collective interests are at odds with private interests. Such situations arise when faced with prioritizing either short-term selfish interests or the long-term interests of a group.

Our model consists of an endowment that is given to all the four players in each round of the game. Each player decides the proportion of his endowment to invest in a public fund (the non-invested part of the private fund is invested in a private fund). This model is an extension of paper [1] that demonstrates the significance of communication in public goods game. The payoff of a player in the public-climate game is determined by:

$$\pi_i = K_i(E_i - C_i) + \frac{N}{4} * \left(\Sigma K_j C_j\right) - L_i \qquad (1)$$

where i = 1 to 4 which represents 4 different countries

Ci is the amount invested in public fund
Ki is return on private investment
Kj is return on public investment
Ei is the initial endowment
Li is the loss that each player suffers
N are the number of players

Due to disparity in wealth distribution in world economies, we have classified countries into four groups namely, lower income economy, lower middle income economy, upper middle income economy and high income economy. This 4-group classification is based on GNI (in US dollars). The return on private investment (*Ki*) has been calculated based on prevailing interest rates in each of the income groups. The return on public investment (*Kj*) is calculated assuming a social dilemma scenario. A player from each of the 4groups is randomly chosen to play the game. After the players are selected randomly, each is given initial endowment to begin with and after each investment round (i.e., a year). The players then take a call and decide as to how much money they will invest in public fund and how much money they will keep for themselves i.e. private use. Money invested in public fund will be utilized to avert climate change. For each player representing economies payoff function (πi) is calculated. If a randomly generated number is less than the probability of climate change occurring, then players bear losses due to climate change. The loss (*Li*) will deduct earnings from that player's payoff function.

4. RESULTS

The countries have been classified into four economies based on GNI which has been taken from World Bank data. According to this classification, the low-income economies are defined as those with a GNI per capita of $1,045 or less in 2013; Middle income and upper-middle income economies are separated at a GNI per capita of $4,125; Middle-income economies are those with a GNI per capita of more than $1,045 but less than $12,746; and, high-income economies are those with a GNI per capita of $12,746 or more. In order to calculate the private return on investment we used bank deposit interest rates provided in the World Development Indicators dataset provided by the World Bank. Four values of interest rates for four world economies are 1.05%, 1.03%, 1.05% and 1.02%. Public return on investment in the social dilemma has been calculated using the following equation (i.e., 1 < MPCR < 4)

$$1 < \Sigma K_j / \mathrm{K_i} < 4$$

We intend to observe how cooperation emerges in the public goods game against climate change, where probabilistic losses occur due to climate change and where players have differing amounts of information about investments made by other players. The probabilistic loss due to climate change is defined by the following equation:

$$\pi_i = 1 - m * \sum_{t=1}^{T} C_i / (N * \sum_{i=1}^{T} E_i * T) \qquad (2)$$

We propose to implement the game described above using Z-Tree software, which is specially designed to implement public-goods game [21]. We intend to investigate whether there is more cooperation against climate change when players suffer probabilistic climate change losses and when players have information on investments being made by opponents. In order to find loss of each economy (*Li*) we have used CO_2 concentrations per capita and the cost incurred by an economy due to increasing carbon-dioxide concentrations. The Global Climate Risk Index 2013 analyzes to what extent countries have been affected by the impacts of weather-related loss events (storms, floods, heat waves etc.) and describe the monetary losses suffered by each country. We have used this Risk Index data from 2011 and that between 1992 and 2011 to compute L_i.

5. CONCLUSION AND FUTURE WORK

Climate change is a worldwide phenomenon that affects us all. Although significant research has been conducted for averting climate change and several rounds of negotiation have taken place to create cooperation, the problem is far from being solved. We propose a public-climate game to study the emergence of cooperation against climate change. For this purpose, we consider two factors that are likely to influence cooperation against climate change: Probabilistic losses due to climate change suffered by all players and the availability of investment information to all players. We believe that both these factors will increase public investments, i.e., increase cooperation behavior against climate change. Our future research using the described public-climate game will hold significant implications for emergence of cooperation against the climate change problem in the real world.

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