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Game Theory and Climate Change

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ABSTRACT

Climate change perceptions and perceived risk in the United States has become increasingly partisan, with increased belief in and support for climate change and regulation among democrats, but decreased belief and support among republicans. These divergences are partly attributable to increasingly partisan news outlet viewership and coverage. We inhabited a game theory model to recognize optimal climate change communication strategy through news media outlets. Actor strategies included whether to converse with pro- and/or anti-climate change new outlets, and to emphasize regulation, renewable energy, whether climate change is real, man-made, and/or causes harm to the United States Payoffs consisted of change in public opinion for each of the candidate topics actors can chose to emphasize. Solutions to games where players have a continuous choice about how much to pollute, games where players make decisions about treaty participation, and games where players make decisions about treaty ratification, are examined. The implications of linking cooperation on climate change with cooperation on other issues, such as trade, are examined. Cooperative and non-cooperative approaches to coalition formation are investigated in order to examine the behavior of coalitions cooperating on climate change. One approach to accomplish assistance is to design a game, known as an apparatus, whose equilibrium corresponds to an optimal outcome.

Keywords-- Engagement, Stewardship, Divestment, ESG, Stranded Assets, Game Theory

I. INTRODUCTION

Game theory incorporates input elements of together the practical person and moderate views of international politics. It is dependable with pragmatism since the players are unspecified to have a unitary will, that is, every government acts as a single agent rather than as some kind of multifaceted association whose decisions consequence from domestic supporting interactions. At the same time, it shows how self-interested behavior can lead to order and welfare-improving outcomes (though it need not necessarily do so), just as the market economy can. The game-theoretic approach does require that governments are able to rank-order outcomes in a manner that is consistent with agent rationality (i.e., a ranking can be assigned to each outcome and the rankings are transitive). Note that the perceived interests of the governments can allow for some weight being given to the well-being of other nations; all that is required is that the outcomes be ranked. In general, the payoffs of a game can be either ordinal (only a rank ordering is possible) or cardinal (different outcomes can be compared on an absolute scale, such as in monetary units). We will focus most of our attention on ordinal rankings.

Global climate change, resulting from the global accumulation of heat-trapping greenhouse gases, has not only become a dominant environmental issue, it is becoming a defining international and social issue. Not only does the prospect of global climate change present potential environmental changes on a scale not seen in recorded history, but the challenges for international social order are unprecedented. Never before in the history of international relations have the nations of the world been confronted with an environmental risk with implications that are so far-reaching in both space and time. And with the sweeping past and prospective inequalities around the world in wealth and human welfare that are somehow connected to the problem of climate change, other international social issues begin to pale in comparative significance.

Exactly why the nations of the world have had difficulty in reaching agreement on limiting greenhouse gas emissions is something of a puzzle. An economic argument can be made that the world will continue to grow wealthier, as it has for centuries, so that reducing greenhouse gas emissions now to avoid climate impacts in the future would essentially be transferring wealth to an even wealthier future generation. However, there are non-trivial risks that the effects of climate change will be catastrophic, and if the current rates of climate change continue, future generations will face a significant and continuing loss in average welfare. For one thing, as higher global temperatures increasingly degrade environmental quality, the marginal value of environmental quality increases, making further environmental deteriorations more costly than typically estimated by economic models. But more frighteningly, global climate change is alone among environmental problems in posing the risk of such vast environmental

changes that the effects could destabilize entire economies, countries, and regions. Some studies of future climate impacts project some dire possibilities: global consumption could fall to less than 1 percent of current levels. This is not future generations doing without four-terabyte iPods; this is future generations in developed countries having to queue up for food and drinking water. Economist Martin Weitzman has observed that even if the probability of these kinds of outcomes is quite small, some precautions might be warranted, even if they might not seem warranted under traditional cost-benefit analyses

Political economy arguments are obviously compelling. It is not news that industry-based interest groups can hijack an entire polity and prevent it from pursuing its own best collective interests. On climate change, some industries and interest groups have used a variety of political and psychological means to stall regulation of greenhouse gases. But even assuming the most craven industrial self-interests, the risk of catastrophe and the fact that these industries and interest groups are exposed to the same risks as everyone else seem to suggest that political economy explanations alone are insufficient to explain the collective paralysis. Another common account is that the transaction costs of solving such a monumental collective action problem are simply too great to overcome. However, the transaction costs of negotiation are not, in fact, prohibitively large, especially given the fact that an international framework has been in place for nearly two decades, and fifteen subsequent international negotiating rounds have been held to hammer out agreements. Given the magnitude of the risk, and the availability of institutions for negotiating international agreements, a transaction cost explanation seems unsatisfying.

II. RELATED WORK

In [1] Dustin Tingley, and Michael Tomz et al presents investigate whether citizens in the United States and 25 other countries maintain reciprocity to covenant with climate change. We determine reserved public passion for intrinsic reciprocity, in which countries restrain their expenditure of fossil fuels if and only if other countries do the same. In dissimilarity, we determine significant support for extrinsic reciprocity, in which country enforce cooperation by linking issues. Citizens sustain financial sanctions flanking polluters and are willing to shame them in worldwide forums, particularly when the polluters are violating a treaty. Cooperation could, therefore, emerge from efforts to link weather with other issue and to implant climate commitments in intercontinental law. We scrutinize this focus with orientation to temperature change for together practical and theoretical reasons. Concerns about climate change are mounting, and lots of now scrutinize it as the major challenge confronting the international community. The Intergovernmental Panel on Climate Change has concluded that the earth is warming and attributes most of the trend to human activities particularly the consumption of fossil fuels. The panel predicts that global warming will trigger widespread flooding of coastal regions, tremendous weather such as droughts and hurricanes, and the disturbance of food supplies.

In [2] Jesse M. Shapiro et al presents a journalist reports to a voter on an unidentified, policy-relevant state. Competing individual interests can formulate claims that challenge the facts but seem realistic to the voter. A reputational incentive to avoid taking sides leads the journalist to description special interests' claims to the voter. In symmetry, the voter can continue uninformed even when the journalist is absolutely informed. Communication is enhanced if the journalists disclose her partisan leanings. The reproduction provides an account of persistent public ignorance on climate change that is consistent with narrative and quantitative evidence. Journalist information to a voter on an unknown, policy-relevant state. Competing individual interests can construct claims that contradict the facts but seem probable to the voter. Reputational inducements to circumvent captivating sides lead the reporter to report special interests' claims to the voter. In equilibrium, the voter can continue uninformed even when the journalist is completely informed. Communication is enhanced if the journalist discloses her partisan leanings. The replica provides a description of persistent community ignorance on climate change that is consistent with description and quantitative evidence

In [3] Stephanie Jean Tsang et al presents although cognitive dissonance is regarded as one of the most recognized causes of selective exposure the mechanism for such causation is still unclear. By inducing dissonance in a web based experiment, this study demonstrates how cognitive dissonance relates to information preferences—the intention to seek congruent information and the intention to seek incongruent information. The findings suggest that perceived hostility with respect to one's belief (cognitive discrepancy) can enhance the intention to seek out for attitude-consistent information. More outstandingly, individuals were establishing to have the purpose to circumvent oppose attitudinal in sequence, but only when they experienced some sort of psychological discomfort (dissonance). In other words, while cognitive discrepancy leads individuals to crave for confirming information, only those who encounter negative emotions are likely to employ avoidance of disconfirming information as a dissonance-reduction strategy. Most importantly, cognitive dissonance is treated as two different variables. In this sense, the role of dissonance (i.e., psychological discomfort) is investigated alongside with cognitive discrepancy (i.e., hostile belief), and the findings suggest that dissonance is vital to make one detour from disagreeing content.

In [4] Jason T. Carmichael, Robert J. Brulle, Joanna K. Huxster et al presents Recent scholarship has identified a large and increasing separate on how Republicans and Democrats observation the subject of climate change. A number of these revise have recommended that this polarization is a creation of methodical labors to extend doubt about the authenticity of climate transform through the media in general and conventional media in meticulous. However, research to date has mostly relied on speculation about such an association rather than empirical evidence. We recuperate on obtainable investigate by accomplish a tentative investigation of the factors distressing national-level, quarterly shifts in public concern about climate change between January 2001 and December 2014. Our analysis focus on the impending role played by four factors that should explanation for changes in levels of concern regarding climate change: (1) media coverage, (2) excessive weather, (3) issuance of chief scientific reports, and (4) changes in financial activity and overseas conflict. Some consequences suggest that partisan media influences attitude in ways expected by announcement scholars who describe Becho chamber^ effects and Boomerang^ effects.
In [5] Tien Ming Lee, Ezra M. Markowitz, Peter D. Howe, Chia-Ying Ko et al presents Climate change is a warning to human societies and natural ecosystems, yet public opinion research finds that public awareness and concern diverge significantly. Here, using an extraordinary review of 119 countries, we determine the relative authority of socio-demographic characteristics, geography, perceived well-being, and beliefs on public climate revolutionize awareness and prospect perceptions at countrywide scales. Worldwide, instructive accomplishment is the single strongest predictor of climate change awareness. Understanding the anthropogenic foundation of environment adjusts is the strongest predictor of climate modify hazard perceptions, predominantly in Latin America and Europe, whereas perception of local temperature change is the strongest predictor in numerous African and Asian country. However, other solution factors associated with public awareness and risks perceptions emphasize involve developing tailored climate communication strategies for personality nations. The consequences recommend that civilizing indispensable education, climate literacy, and public accepting of the local dimensions of climate transform are crucial to public appointment and maintain for climate action.

III. PROPOSED PROCESS

This paper examines how investors and companies might interact with each other to mitigate climate change risks. The subject of study is the decision making processes of both oil and gas companies and their investors, and critically how their decisions influence each other. The study of how individuals or organizations (hereafter called agents) make decisions is called decision theory.

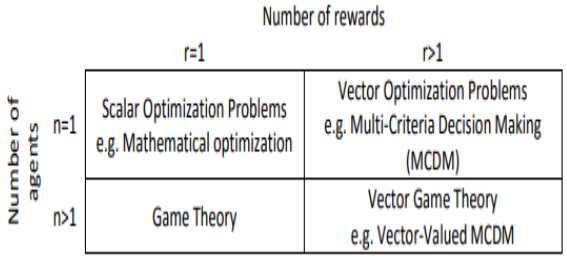

Fig 1 Game theory process

Decision theory is the study of how a single rational agent maximizes their outcome, especially under uncertainty, and has found application among engineers, economists, psychologists, computer scientists, and policy maker. Decision theory has its origins in Expected Utility Theory. It provides a high-level overview of decision theory domains based on the number of agents and the number of rewards they receive, adapted in Figure. As the decisions and outcomes of investors and their companies are clearly interrelated, game theory tools will be used to examine the decision making of various agents.

1) Natural System

The modeling of climate and the evolution of temperature is based on energy balance relationships between incoming and outgoing radiation. The incoming short-wave radiation is 340 W/m2 when averaged over the surface of the earth. Approximately one-third of this is directly reflected back to space. In equilibrium, the resulting net short-wave radiation must be balanced by the outgoing long-wave radiation. At a pre-industrial equilibrium state, the incoming and outgoing energy fluxes were equal, and the global mean temperature was therefore constant on the average. However, the post-industrial revolution period introduced an anthropogenic perturbation to the energy budget through the use of fossil fuels. This perturbation is usually denoted by F (measured in W/m2) and is called forcing. Due to the perturbation, the incoming energy flux is larger than the outgoing flux, which leads to increasing temperature
Under a perturbation $F(t)$ the evolution of global mean temperature can be described by

$$\frac{dT(t)}{dt} \equiv T(t) = \sigma[F(t) - kT(t)], T(0) = 0$$

2) Control System

Control systems can make the target functions as intended. Without control systems there could be no regulated environment. Control systems are most often based on the principle of feedback, whereby the target variables to be controlled are compared to the desired references and the discrepancy is used to compute

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corrective control action. Based on feedback control system, we propose an evolutionary game control approach. The payoffs of individuals decline due to the environment change, then affect the next decision-making process. The individuals will evolve their behaviors towards the new equilibrium states in the evolutionary process where they may shorten the deviation between their payoffs and the optimum. Therefore, the ever-rising error between the target variable and the reference will be eliminated.

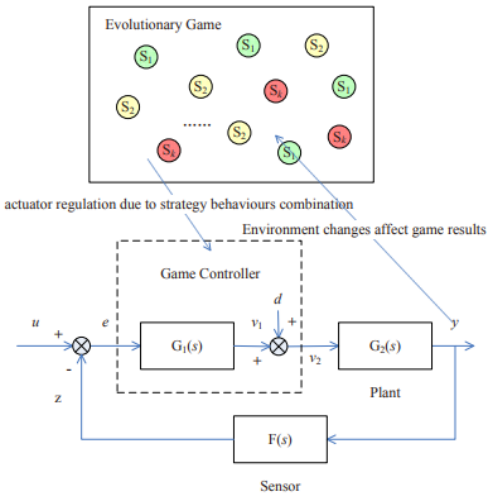

Fig 2 Control system method

3) Game Theory

Games are fundamentally arithmetical objects, to which it has developed into in fact designer in economics to have recourse. The employ of game theory in this book, however, discover its roots less in fashion than in realizing that economics per se does not offer conceptual tools that are wealthy adequate for commerce with the two most necessary aspect of climate change: namely, (i) the deficiency of a supranational influence that can enforce its policy decisions on the nation-states, and (ii) the externality has public outstanding uniqueness – though it does not fit the characteristic notion of a community good.

Traditional game theory typically analyzes an interaction between two players and deals with the problem, for example, how each player can maximize her or his payoff in a game given that each player do not know what the other player do. There are four basic elements in a game: players, information, strategies and payoffs. And the concept of rationality are usually assumed in a game for the individuals come to play. However, evolutionary game theory does not necessarily reply on rationality. It considers a population of players interacting in a game. Individuals have fixed strategies and interact randomly with each other. Payoff is then interpreted as fitness, and success in the game is translated into reproductive success. Strategies that do well reproduce faster. This is straightforward natural selection.

4) Game Theoretic Structure

The difficulty of providing a global public good can be studied using a simple game theoretic set up based on John Nash's early contributions. Using this approach, interactions among countries are modeled as a one-shot simultaneous game and lead either to full cooperation or to free-riding. If the benefits from an higher provision of the global public good are widely dispersed in space and in time and costs are instead high and private as in the case of climate change control, free-riding inevitably prevails and the global common resource is spoiled, leading to the well-known ''tragedy of the commons''.

However, the strategic interactions outlined above are quite crude and do not correspond to the observed behavior of countries facing global externalities. Indeed, international cooperation often does exist, albeit at different degrees, on a wide range of issues of common interest. In particular, over the last decades, the emergence of several international treaties to protect global common goods has been observed. These issues are at the core of the recent developments of coalition theory. Let us consider the simplest case of a simultaneous one-shot game. This game can be ideally decomposed into two stages. In the initial step – the coalition game – countries desire whether or not to cooperate. In the second step – the policy game – countries choose the optimal level of carbon emissions. The decision in the first step is influenced by several factors, including what countries perceive to be the optimal strategy of all other countries in the second step of the game

5) Game Theory Process

Game theory is often applied by assuming that the game is given, and used to predict the behavior of participants. But an area of game theory known as implementation theory treats the desired outcome as given, and asks how to design a process that leads to this outcome. An example of such as process could be the negotiations for an international environmental agreement. This approach may help us design processes that are more likely to lead to cooperative outcomes. Addressing the free-rider incentives associated with climate change mitigation requires that we find mechanisms to facilitate cooperation between states. One such approach is international treaty-making.

Game theory can offer functional insights when permit for debates such as these. In fact, there has been a parallel debate in the game theory literature (see Section 3) on whether cooperation is more likely to arise from a grand coalition of all countries, or from smaller coalitions that do not include every country. A grand coalition, if it existed, would lead to more cooperation. But it is may not be the case that such a coalition would be stable. It is also not clear how such a coalition would form in practice. Game theory provides insight both into the stability of coalitions,

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and the implications of different processes for forming coalitions. When using a model to help understand a problem, it is important to be aware of the limitations of the model. Many applications of game theory necessitate that conclusion makers are rational. That is, they have clear preferences, form expectations about unknowns, and make decisions that are consistent with these preferences and expectations

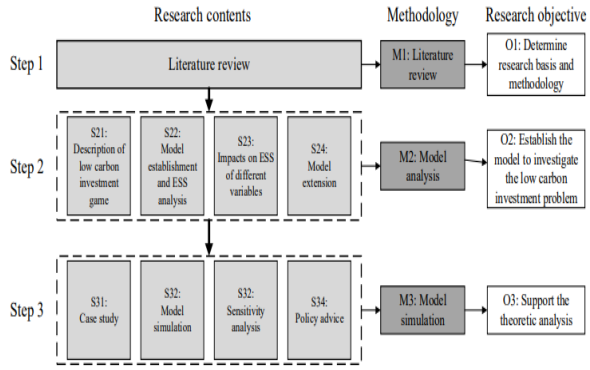

Fig Game theory process

6) Game Theory Models

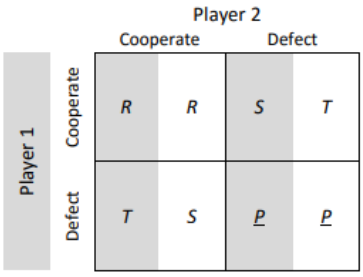

Fig 3 Game theory models

Engagement between an investor and a company on an ESG issue is characterized as a social dilemma. A social dilemma occurs when agents individually seek higher payoffs for antisocial behavior to the detriment of their collective interests. The prisoner's dilemma is the canonical social dilemma and is used in this section to explore interactions between two agents.

A non-cooperative outcome is one in which the company, the investor, or both fail or refuse to deliver on their engagement. An investor may lose interest in the subject or even divest from the company, and a company board may defect from its commitment to the investor. Characteristic of the IPD, the reward of mutual cooperation vests continually over time, whereas the temptation to defect delivers immediate utility to that agent followed usually by less cooperative future outcomes

1) Analysis

Games can be investigate in two ways: noncooperative analysis of games focuses on the strategy that every player would undertake to exploit his possess payoff and the subsequent equilibrium that would be reached when all players do so, while cooperative analysis of games focuses on how incentives can be designed such that the players will adopt the strategies to attain the result with the greatest total payoff

In the container of the climate change trouble there is distinct room for apply cooperative game analysis as the sum of benefits (i.e., damages prevented) from controlling climate change outweighs the total costs of controlling climate change. However, though the total benefits surpass the entirety costs, the benefits and costs may not be spread out consistently amongst the countries in that the costs may be higher than the reimbursement for several countries except the countries are identical. Because in actuality the countries are certainly not matching, not each country would be willing to engage in controlling climate change. To incentivize every country to connect in controlling climate change, a solution obtainable by cooperative game theory is that of side payments. If the principle that the sum of benefits from controlling climate change exceeds the costs of controlling climate change is indeed correct, then it might be possible to distribute the collective additional that will be generate such that after the side payments, every country is better-off. Designing such side payments is a trying task and this is where the book becomes fairly technical.

2) Non-Cooperative Games and Climate Change

In non-cooperative games, players make decisions independently. We define some of the relevant ways of representing non-cooperative games and solution concepts. We illustrate these definitions with a number of examples that are relevant to climate change.

DEFINITION 1

The normal form representation of a game specifies:

1. the set of players in the game (in the context of climate change these will often be countries), N;
2. a set S of strategy combinations, each strategy combination assigns a strategy to each player;
3. and the set of payoffs $\Pi = \{\pi i : i \in N\}$ received by each player for each possible strategy combination. Each payoff πi assigns a real number (the utility1) to a strategy combination.

The normal form representation of a game is sometimes also known as the strategic form of a game. When we consider a player i and strategy combination s, we will often write s−i to denote the strategies of players other than i, and write s = (si , s−i).

DEFINITION 2

A Nash equilibrium for a normal form representation of a game is a strategy combination $s^* = (S_i^*, S_{-i}^*)$ where for all players i ∈ N, we have that

$$\pi_i(S_i^*, S_{-i}^*) \geq \pi_i(S_i, S_{-i}^*)$$

In other words, in the Nash equilibrium every strategy is the best response to the best strategies of the other players. An important variation of the concept of a normal form game allows players to play mixed strategies. Instead of choosing a particular strategy, each player assigns a probability to each strategy.

IV. CONCLUSION

One broad conclusion concerning climate policy that follows from this work is that financial transfers to balance the costs and benefits of controlling climate change are a necessity and not a matter of approach or choice. In the absence of transfers, sovereign and peaceful countries, unless they are identical, cannot be induced to take actions that are necessary for controlling climate change. A conclusion is drawn in the final chapter of this book. It summarizes both the theory and the policy implications of this work. It also argues troubles that have been left open and that might be address in future occupation. In its simplest form, climate revolutionize mitigation is a prisoner's dilemma. The prisoner's dilemma has a Nash equilibrium that occupies players acting non-cooperatively in a method that is generally sub-optimal. When countries have an incessant selection about how much to infect, the Nash equilibrium involves much more pollution than is optimal. This is why climate change is sometimes known as a social dilemma. Normal form games such as this help us to understand the free-rider problem, but do not tell is about the sequential nature of strategic behavior. Being able to do this is important for addressing the social dilemma.

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