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Avoiding disastrous climate change is possible but not inevitable

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What the world does or does not do about climate change will have profound implications. If the world fails to act, we may cross a climate tipping point, with disastrous consequences all around. No country by itself can prevent this, but a substantial number of countries working together can avert disaster. Collectively, we know what we need to do. However, can we agree on what each of us should do? Can we be assured that, if we act, others will fulfill their pledges? An experimental paper in PNAS (1) provides reasons for optimism and despair, optimism because, with communication, outcomes improve; despair because intransigence by a few countries can block progress. A key impediment to success, this paper (1) shows, is overcoming historical inequities.

This paper by Tavoni et al. (1) is best appreciated by considering a previous paper by Milinski et al. (2), also published in PNAS. An experimental game is played by groups of six students. Each student is given an endowment of €40 and must decide whether to contribute €0, €2, or €4 in each of 10 periods to a collective effort to avert dangerous climate change. (You might think of these values as representing the costs of reducing emissions by various levels.) The identities of the players are private, but everyone's contribution is made public after each round. If all six students collectively contribute €120 or more by the end of the game, each student gets to keep the amount of money he or she has left. If, however, contributions add up to less than €120, each student loses all the money he or she has left with a probability of 90%, 50%, or 10%, depending on the treatment.

Notice that, collectively, the students will want to contribute either €0 or €120. Any other total contribution will be wasted. For example, if €119 is contributed, the prospect of disaster will be unaffected and the money contributed will be lost. If €121 is contributed, disaster will be prevented but the same outcome would have been assured by contributing €1 less.

If students contribute €120, they are sure to get a collective payoff of €120. If they contribute €0, they will get an expected payoff of €24 if the probability of disaster is 90%, €120 if this probability is 50%, and €216 if this probability is 10%. Their collective-best contribution thus

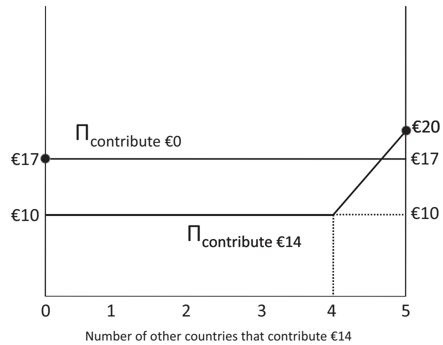

Fig. 1. This is a highly stylized representation of the equity-treatment game modeled by Tavoni et al. (1). It assumes that every country has already contributed €6 and must now decide between contributing an additional €0 or €14. These are assumed to be one-time contributions, paid in a single period. The vertical axis shows the payoff a country expects to get by contributing these amounts. The horizontal axis shows the number of other countries that contribute €14 rather than €0. The figure shows that if four or fewer other countries contribute €14, each country has an incentive to contribute €0. If, however, every other country contributes €14, each country has an incentive to contribute €14. There are thus two (pure strategy) Nash equilibria in this game. In one, every country contributes €0. In the other, every country contributes €14. Every state is better off in this second equilibrium. The question is whether they can coordinate on this second equilibrium.

depends on the probability of disaster and the students' aversion to risk. The result that Milinski et al. (2) obtained for the 90% treatment was especially startling. Disaster was avoided only half of the time, even though the collective incentive to avoid disaster was powerful. Reading this paper, one cannot help but ask, "Are people really this foolish?"

To understand what is going on, it helps to examine the private and not only the collective incentives to contribute. If no one else contributes, each player is better off not contributing. However, if the others contribute, say, €20 each, every student will want to contribute €20 under the 90% treatment. In this game, there is strong incentive for each student to contribute only if assured that the others, or at least enough others, will contribute. It is possible for people to be individually rational and collectively foolish.

The paper by Tavoni et al. (1) explores the robustness of these previous results while at the same time casting the experiment in a more realistic light. In particular, Tavoni et al. (1) allow the students to make pledges for how they intend to contribute in the future. They also construct treatments in which inequities appear attributable to different histories. Unfortunately, they limit their analysis to the 50% probability of disaster.

Are these experiments plausible representations of the game countries are playing now? Some differences stand out. The real climate change game is being played by 192 countries rather than 6. Catastrophe will cost us more than €40 each.

Less obvious differences are also important. For example, both papers assume that we know that a threshold exists and that we know precisely where it is and how to avoid it. This assumption substantially strengthens the incentives for countries to act collectively. It also gives communication its bite. The real challenge, however, is riddled with uncertainties. Although the Copenhagen and Cancun agreements say that a temperature change greater than 2 °C should be avoided, other thresholds have been identified (3), and the uncertain relationship between concentrations and temperature makes it difficult to know how to meet a given temperature threshold. As well, both papers assume that efforts short of and in excess of the threshold are wasted, whereas every ton of emissions prevented reduces "gradual" climate change in addition to the probability of triggering "abrupt and catastrophic" climate change.

These matters aside, what can we learn from the Tavoni et al. (1) paper? Start by considering the game that is played without communication. In game of Milinski et al. (2), with 50% treatment, only 1 of 10 groups cooperated. In the game of Tavoni et al. (1), by contrast, 5 of 10 groups avoided catastrophe. Why the difference? There are two reasons. First, in the game of Tavoni et al. (1), the computer chose a contribution of €2 per round for every player in each of the first three rounds. Hence, if each player contributed €0 in each of the remaining

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rounds, each would get an expected payoff of €17, whereas if each contributed €2 in each of the remaining rounds, each would get a sure payoff of €20. By contrast, in the experiment of Milinski et al. (2), with 50% treatment, the expected payoff was the same (€20) whether or not disaster was avoided. The incentives to avoid catastrophe are thus stronger in the game of Tavoni et al. (1). Second, the contribution of €2 per round made by the computer in the first three rounds of the game by Tavoni et al. (1) is a focal point (4), shaping how the players will play in subsequent rounds. These payments not only reflect the equal contributions that will assure avoiding disaster but also represent precedent.

Communication is important in this game because there are multiple Nash equilibria (Fig. 1) and countries will wish to coordinate on the one that is mutually preferred. In the paper by Tavoni et al. (1), the players could not negotiate but were allowed to pledge how they intended to play in future rounds. These pledges could be made at the end of rounds 3 (essentially, the start of the game) and 7. After this, the students were shown what would happen if everyone adhered to their pledges—whether catastrophe would or would not be avoided.

The Copenhagen Accord, negotiated in December 2009, works in a similar way. This agreement, which is nonbinding, identifies a threshold to be avoided (2 °C) and then requires that countries submit their individual targets for reducing emissions, presumably with the hope that when added up, these targets will ensure the threshold is met.

In the experiment by Tavoni et al. (1), 7 of 10 groups allowed to pledge avoided disaster. Moreover, compared with the no-pledge treatment, total contributions were closer to their collectively optimal values (€120 when disaster is avoided and €36 when disaster is not avoided). The differences are not huge; however, the advantages to communication are relatively modest in this game. If communication were allowed for the 90% treatment investigated by Milinski et al. (2), I am confident that the effect would be much stronger.

Communication is of value in this game only if the information conveyed is trusted. Also important is whether the students who communicate prove to be trustworthy. As noted by Tavoni et al. (1), the closer actual contributions were to the amounts pledged, the higher were the chances of disaster being averted.

When communication was prohibited, only 2 of 10 groups averted disaster.

Inequality was introduced in a special way. In two treatments, the computer chose contributions of €4 per round for half of the players in each group and €0 for the other half. This procedure was meant to reflect the notion that the wealthy countries (those with a higher endowment at the end of the first three rounds) used up more than their fair share of the catastrophe-avoiding carbon budget in the process of becoming wealthy. Arguably, this imposes on the rich an "historic responsibility" to take the lead in reducing emissions now.

Inequities make coordination harder. The students with reduced endowments, "the poor," may feel that the others, "the rich," ought to contribute more in the future. However, the rich may feel that the past is past. The rich also have a relatively weaker incentive to contribute. They get the same expected payoff (€20) whether they contribute €0 or whether they and all other countries contribute €20. By contrast, the poor gain more if every state contributes €20, relative to the payoff they can expect to get by contributing nothing (€14).

How might this game be played? Every student could contribute €2 in each of the final seven rounds, but this would fail to correct the historical injustice and does not give poor students an edge relative to contributing €0. Another possibility, as noted by Tavoni et al. (1), is that the rich could contribute €3 each, and the poor €1, in every future round. However, this would make the rich worse off relative to the payoff they could expect to get by contributing €0 and overcompensates the poor for their historical disadvantage. Finally, the rich could agree to contribute €4, and the poor €0, in rounds 4 through 6, with every player contributing €2 thereafter. This would restore equity and ensure efficiency but requires that the rich forfeit their historical advantage when they cannot gain by doing so (compared with contributing €0, this proposal makes them neither better off nor worse off in expected value terms). To accept this proposal, the rich would have to be motivated by a strong sense of fairness.

How did the students play in the unequal treatments? When communication was prohibited, only 2 of 10 groups averted disaster. As expected, inequality made coordination harder. When the students were able to make pledges, however, their success rate improved a lot, with 6 of 10 groups contributing at least €120 in total. Indeed, communication nearly eliminated the handicap of inequality. The reason for the improvement was not attributable to communication alone. What mattered was the willingness of the rich countries to concede their early advantage by contributing more than poor countries in later periods, coupled with their ability to communicate their intentions and the willingness of the poor countries to trust them.

This last finding is especially encouraging, but the actual negotiations have been framed in a way that makes this kind of concession very difficult. Countries have been asked to negotiate reductions in emissions at some future date relative to a base year. Because the "business as usual" emission growth paths are unobservable, states cannot know if the pledges being made imply equal or unequal sacrifices, something negotiators call the "the comparability problem." Perhaps the most important practical implication of the paper by Tavoni et al. (1) is that negotiations should be reframed to bring equity concerns out in the open.

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