GAME THEORY

Building up cooperation

Can we achieve the ambitious mitigation targets needed to avert dangerous global warming? Research now shows that local sanctioning institutions may succeed where global agreements fall short.

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In spite of some 18 Conferences of the Parties, global efforts to curb emissions have failed to achieve tangible results (Fig. 1). Although participation is broad — there are 192 parties to the Kyoto Protocol under the United Nations Framework Convention on Climate Change (UNFCCC) — only a handful of nations are actually bound to reduce emissions. Furthermore, the lack of a supranational sanctioning institution means that countries are effectively free to disregard their commitments or to withdraw from the agreement (as Canada did). Due to the inherent trade-off between the breadth of the treaty, in terms of number of acceding countries, and the depth of the emission-reduction commitments, game theorists have come up with the dismal prediction that little will be achieved by a self-enforcing agreement. Either the number of signatories will be small, or many countries will partake in a shallow agreement and achieve only modest reductions[1,2]. In *Nature Climate Change*, Vasconcelos and colleagues[3] provide reasons for optimism: local climate governance may be less riddled with barriers to cooperation than international agreements.

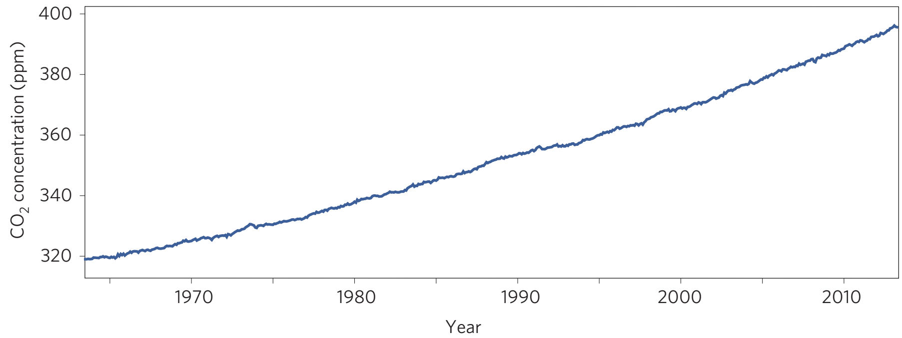

Figure 1 | Concentrations on the increase. Despite much negotiation around a global climate agreements, CO_2 emissions show no sign of slowing. On the contrary, concentrations have constantly increased since the first UNFCCC conference was held in 1995, and in May 2013 they have temporarily reached the 400 parts per million milestone. Data from the Scripps Institution of Oceanography; available via http://go.nature.com/hTRIZH

Vasconcelos *et al.* build on an evolutionary game theory model[4] that investigates how cooperation would evolve in a game where players decide whether to invest in a series of collective projects that — if sufficient funds are provided — ensure avoidance of an uncertain, but potentially sizeable loss. That is, unlike in the more commonly used public goods games[5] where contributions to the common pot increase in the welfare of the community, in this variant the aim of contributing money is to avoid a catastrophic loss. The undesired event is likely to occur if public investments fall short of a threshold (reached when the majority of players cooperate and contribute money to avoid the loss).

Akin to the game described above, nations can coordinate actions to mitigate climate change in two ways: they can avoid uncertain losses associated with dangerous climate change by collectively investing enough money to stabilize CO_2 concentrations at safe levels (for example, the 350 parts per million suggested by ref. 6), or they can gamble on the climate commons by underinvesting in it and hope to get lucky. Unsurprisingly, the model used by Vasconcelos *et al.* confirms that this coordination task is easier when the risk perception (that is, the perceived probability of disaster occurring when the threshold is not met) is high, a feature that unfortunately cannot be leveraged at present[7]. The good news is that precisely under the challenging circumstances that characterize climate change — the need for large investments to avert a threat that is perceived as distant — the model shows that self-organisation may provide a helping hand.

Vasconcelos *et al.*[3] investigate the performance of a bottom-up coordination process by assuming that, to deal with global climate change risk, players organize themselves in groups at the local level. They do so through successive agreements that set moderate climate targets that are potentially sufficient to deliver the long-term goal. Within the groups there are members who invest in climate protection (cooperators) and members who do not invest (defectors). The researchers are interested in testing the effectiveness of local institutions versus global agreements by modelling the ability to sanction defectors, either at the group level or globally. To this end they extend the model and include punishers, who invest in climate protection like cooperators, and in addition contribute to a sanctioning institution. In other words they pay a 'tax' to maintain a sanctioning institution that targets free-riders, and does so in proportion to the number of punishers — provided that a sufficient number of members contribute to maintain it. In this setting, climate protection contributions below the threshold are wasted: punishers belonging to groups with an insufficient number of investors will not be able to maintain the sanctioning institution.

Similar to climate policy contexts where parties experiment with strategies, players in this game can switch between strategies (defecting, cooperating and punishing) according to what is most advantageous at a given time, and can also explore alternative actions.

The results are stark. Local sanctioning institutions outperform global ones. Vasconcelos and colleagues highlight the effectiveness of what Ostrom termed polycentric governance — the greater potential of coordinated action emerging from players at various scales compared with a comprehensive international treaty to bring about progress[8]. What can we learn from Vasconcelos *et al*. in terms of climate governance? Importantly, the threat of sanctions at the domestic level may stimulate investments aimed at avoiding catastrophic climate change. However, there are obstacles to climate cooperation that are not captured in the analysis, and are likely to impede efforts (both local and global). First, in the face of uncertainty about where the tipping point for 'dangerous climate change' lies and consequently of the magnitude of the effort required to avert it, the ability of a threshold to catalyse cooperation is greatly reduced[9]. Second, unlike in the model, we live in a highly asymmetric world. Two elements shaping the outcome of the game are the wealth of nations or regions, and the risk perception. Asymmetry in the first undoubtedly impairs cooperation, due to the parties' difficulty in overcoming historical inequities and fairly splitting the burden[10]. In addition, it is likely that considering spatially heterogeneous risk perception (a realistic feature given regional differences in vulnerability and behaviour) would lessen the spread of cooperation.

In summary, the task of keeping CO_2 emissions at bay is daunting, as the concentration trajectory reminds us. For the transformative change in technology and behaviour that is required to avoid potentially catastrophic warming, unilateral action at the local scale will play a crucial role, as Vasconcelos and colleagues show[3]. The question remains whether these efforts, when added up, will suffice to ensure that the safe climate boundary is not crossed. ❐

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