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## Evolutionary escape from the climate dilemma

### Comment on “Climate Change Governance, Cooperation and Self-organization” by Pacheco, Vasconcelos & Santos

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Jorge M. Pacheco, Vítor V. Vasconcelos and Francisco C. Santos take stock of a growing body of research they have produced in recent years, with the aim of shedding light on whether bottom-up agreements can suffice in promoting the high levels of cooperation needed to avert dangerous climate change [1]. The current state of affairs leave little reason for optimism, given the steady rise in CO<sub>2</sub> emissions [2]. The UNFCCC approach to seeking universal participation has thus been called into question, both by some policy makers and by academics who have established pessimistic theoretical predictions concerning the limited ability of international environmental agreements to improve upon what nation states would do in the absence of an agreement. Game theorists have predicted that *self-enforcing* agreements are likely to comprise only a handful of countries committing to unambitious emission abatement targets [3]. Clearly, this is incompatible with stabilizing CO<sub>2</sub> concentrations at levels that significantly constrain the likelihood of dangerous climate change. The question then arises as to whether we can deliver on ambitious abatement targets by leveraging on unilateral action by countries or other sub- or supra-national entities (e.g. cities or blocs). This has recently been analyzed in game-theoretic contexts [4, 5], as well as in the governance literature [6], with more optimistic predictions compared to traditional models focusing on overarching agreements.

Pacheco and colleagues have shed new light on the issue by analyzing the formation of climate treaties with evolutionary game theory. Briefly, the common setup utilized in the papers they review in [1] is that of a threshold public goods game (TPGG), where groups failing to coordinate on a minimum contribution face a high probabilistic loss [7]. Such features mirror the idea that a minimum number of participants is required in international environmental agreements, and that miscoordination on the target (underprovision of the public good) can lead to catastrophic consequences due to climate change. They enrich this setup with realistic features such as wealth inequality, threshold uncertainty and the presence of sanctioning institutions. The model departs from previous treatments of this TPGG by focusing on the dynamics of strategy adoption (here modelled as evolutionary, in the sense of imitation of successful strategies), rather than on equilibrium behavior. A significant advantage of the evolutionary framework is that it allows discriminating between equilibria in terms of their stability, or prevalence over time.

One of the main conclusions that Pacheco *et al.* [1] reach is that risk perception crucially determines the prospects of success: when the threat of collective disaster is perceived as remote, cooperation cannot be sustained, no matter what the other model specifications are. Conversely, high-risk perception especially when coupled with cooperation nucleating in small groups and expanding into larger ones, allows for an ‘evolutionary escape from the climate dilemma’. An important caveat to this promising way out of the climate stalemate is that it is hostage to the

presence of uncertainty on the threshold. The authors find that group achievement in avoiding it sharply declines when only the distribution of the threshold is known, leading to a regime shift. This finding confirms theoretical and empirical work showing that resource variability and disagreement over the location of the tipping point can trigger a collapse of cooperation [8, 9].

Sadly, at present the scientific and political discussions over the location of the threshold for dangerous climate change do not converge on a single value, whether in terms of admissible CO<sub>2</sub> concentrations or temperature increase [10]. Shedding light on the risks associated with dangerous climate change and reducing scientific uncertainty thus appear to be further public goods whose provision is a pre-requisite for effective climate cooperation.

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