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How dynamic adaptive policies shape climate change mitigation trade-offs under uncertainty

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While scientific evidence on the considerable risks driven by anthropogenic climate change builds, it is far from trivial to agree on one among the many globally optimal, long-term decarbonization strategies proposed so far in the literature. Dynamic adaptive policy pathways might offer a useful alternative decision analytical approach that incorporates uncertainty and learning, potentially providing greater consensus. The idea is to choose appropriate signposts to monitor and determine appropriate corrective action as they are approached, adjusting as events unfold.

Identifying abatement strategies from the optimization of climate-economic dynamics with endogenous learning can pose non-trivial computational challenges. This problem has been commonly tackled with Integrated Assessment Models (IAMs) in a dynamic programming framework, either by reducing the complexity of the model or by keeping the number of uncertain dimensions and policy decision points low. Furthermore, this type of analysis is almost always performed in a single-objective optimization setting. Here, we consider an alternative approach: we preserve the complexity of a commonly used IAM, i.e. the globally-aggregated Dynamic Integrated model of Climate and Economy (DICE), and combine it with evolutionary multiple-objective direct policy search (EMODPS) techniques. We focus on observable signals related to global temperature increase, gross world product levels and backstop availability to inform policy decisions against uncertainties in climate sensitivity, economic productivity and carbon-free technological progress. We represent the relationship between these signals and the corresponding abatement decisions with radial basis functions. This formulation, along with an auto-adaptive evolutionary optimizer, allows for a computationally efficient exploration of an otherwise intractable space of decisions and objectives, where decisions involve abatement actions updated at each time step and objectives include both environmental and economic metrics.

Our approach generates abatement strategies that clearly outperform (in terms of Pareto dominance) traditional intertemporally optimized open-loop strategies. With a more accurate understanding of the economic and climatic trade-offs at play, and the ability to adapt to progressively resolving uncertainties, the new framing has the potential to achieve greater consensus among climate decision makers with different preferences for objectives or priors for uncertain parameters.