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The primary cause of global warming is the rise in the concentration of greenhouse gases (GHGs), particularly carbon dioxide (CO2). Before the Industrial Revolution there was an equilibrium between the inflow of greenhouse gases (GHGs) and the carbon outflow absorbed by oceans and plants. However, the increased use of fossil fuels—such as coal, natural gas, and oil—is recognized as the primary human activity that has disrupted this balance. It led to an average yearly increase in CO2 emissions of over 3 percent in the 2000s.

Policies designed to control GHGs imply domestic tradeoffs and international externalities, resulting in domestic and international conflicts and influencing the policies' feasibility and implementation. In this respect, we have investigated two quantitative aspects: (a) the impact of internalizing international externalities and (b) the damage associated with a short-term view of climate policies. In this respect, we adopted the innovative (in this field) idea of model predictive control to formalize moving-horizon policy strategies and, thus, to build counterfactuals characterized by a different horizon for policymakers' plans.

We propose the concept of moving-horizon strategic interaction, in which policymakers can anticipate the outcomes of their actions and those of their opponents within a finite moving horizon. The policymakers must solve an optimal control problem repetitively in a receding time horizon approach at each sampling moment. However, only the initial control action is implemented at each instant. The resulting policy equilibrium that aligns with this optimization approach is the NMPC Nash Equilibrium. Such an equilibrium is characterized by varying dynamics of relevant variables based on the length of the policymakers' time horizons.

We used a simple global public good game involving two countries or two blocks of countries. Each participant must balance the competing priorities of promoting economic growth and reducing fossil fuel consumption, impacting the Earth's climate. As anticipated, we used the NMPC Nash Equilibrium to solve this game. Specifically, we analyze strategic interactions in which policymakers optimize decisions using a rolling horizon scheme that periodically updates input data information. To better understand this concept, consider policymakers who engage in strategic interactions over a fixed policy horizon, such as 20 years. In the year 2022, each policymaker calculates his or her optimal policy by considering the reaction of the other policymaker over this fixed horizon (2022-2042). These optimal policies (open-loop Nash equilibrium) are only implemented for the first period (2022). In the second period (2023), policymakers recalculate their optimal policies using the same fixed horizon, which is now shifted forward by one period (2023-2043). Once again, only the first period (2023) policy is implemented. This process is repeated in subsequent periods.

Within the above-described framework we conducted two experiments that simulated the CO2 concentration and temperature dynamics during the next 80 years (2019–2100). The first experiment evaluates the impact of the absence or presence of international agreements in limiting CO2 concentration. In the second experiment we examine the issue of policymakers' short-termism, which refers to their tendency to prioritize the current effects of their policies over their long-term impact.

In Experiment 1, as expected, the non-cooperative equilibrium results in a higher CO2 concentration level than the cooperative policies. Initially, there is no significant difference in CO2 concentration between the two policies. However, after 2039, we observe a significant increase in the non-cooperative scenario, with CO2 concentration reaching 1456 ppm by 2100. This level of CO2 concentration corresponds to a surface temperature increase of approximately 5.6°C above the pre-industrial level. In contrast, under coordinated policies, CO2 concentration only reaches 700 ppm by 2100, resulting in a temperature increase of 3.2°C above pre-industrial levels. These results align with the wide confidence interval identified by the IPCC, which predicts CO2 equivalent concentration levels between 750 ppm and 1,300 ppm in 2100 across approximately 300 scenarios without additional mitigation. This range corresponds to a temperature increase of 2.5°C to 7.8°C.

In Experiment 2 we introduced a marginal change to the policy horizon, increasing it by one year. Our findings indicate that policies designed by policymakers who exhibit myopic behavior will result in a higher level of CO2 concentration compared to those designed by less myopic policymakers. When evaluating temperature changes over the next 80 years, less myopic policymakers anticipate a lower CO2 concentration, resulting in a temperature increase of approximately 4.2°C above the pre-industrial level. In contrast, policies designed by myopic policymakers lead to a temperature increase of approximately 5.6°C above pre-industrial levels. Short-term thinking leads to underestimating the relative cost of CO2 concentration compared to less myopic decision-making. Additionally, we observe that CO2 concentration follows concave dynamics under high myopic policies. Interestingly, less myopia leads to convex dynamics, which is more similar to the outcomes of the RICE model.

In summary, our research indicates that non-cooperative strategies result in outcomes that closely align with the worst existing forecasts. At the same time, coordination is particularly effective in reducing emissions by internalizing global externalities. Without international coordination, our simulations predict a level of CO2 concentration that would increase the Earth's surface temperature by approximately 5.6°C above the pre-industrial level by 2100. However, if governments coordinate their actions, CO2 concentration can be significantly reduced, lowering the global mean surface temperature by approximately 2.4°C by 2100. Nevertheless, coordination alone is insufficient to achieve sustainable emission levels, and other climate policies are required to reduce CO2 concentration levels. We also show that slight differences in the policy horizon length can lead to significantly different outcomes. We observe a clear difference between policymakers with higher and lower myopia. However, even with less myopic policymakers, unsustainable emission pathways and severe temperatures in 2100 will still occur without any cooperation to reduce emissions.

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