POLICY RESPONSES TO CLIMATE CHANGE

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EXECUTIVE SUMMARY

Cai, Brock, Xepapadeas, and Judd [1] have built a model of Dynamic Integration of Regional Economy and Spatial Climate under Uncertainty (DIRESCU), incorporating a number of important climate science elements that are missing in most integrated assessment models. These include spatial heat and moisture transport from low latitudes to high latitudes, sea level rise, permafrost thaw, and tipping points. Using this more realistic model of the world economy and climate, we study policy responses to climate change under cooperation and various degrees of competition among regions. We find that other assessment models that are missing elements of climate science lead to significant bias in important policy variables such as the social cost of carbon and adaptation.

RESEARCH CHALLENGE

Leading integrated assessment models assume that climate damages are related to the mean surface temperature of the planet. But climate science shows that when the climate cools or warms, high-latitude regions tend to exaggerate the changes seen at lower latitudes due to spatial heat and moisture transport. This effect is called polar amplification (PA). Thus, the surface temperature anomaly is differentiated across spatial zones of the globe. The low- (high-) latitude regions would be hotter (colder) if poleward heat transport were absent; hence, damages in the low-latitude regions would be higher (lower) than in the high-latitude regions.

To address the tipping points and solve the dynamic stochastic programming problem, we adopt the computational method in DSICE [2], developed by Cai and Judd in the past four years using GLCPC allocations on Blue Waters. The computational method is parallel backward value function iteration using the master-worker structure—the master assigns N tasks for workers to solve in parallel and then gathers the results of these tasks from workers. Our code shows high parallel efficiency, with an almost linear speed-up from 30 nodes to 5,000 nodes.

RESULTS & IMPACT


In 2018, Cai, Brock, Xepapadeas, and Judd released a National Bureau of Economic Research working paper [1] that is under review for publication in a prestigious economic journal. The paper builds the DIRESCU model, studies optimal climate policies under cooperation and various degrees of competition among regions, and finds that excluding some of the elements of climate science leads to significant bias in important policy variables such as the social cost of carbon and adaptation.

WHY BLUE WATERS

Our parallel computational package requires low-latency communications because the algorithm uses the master-worker structure and needs frequent communications between the master and workers. Our problems are large. For example, the DIRESCU model has 10 continuous state variables and one binary state variable, as well as eight continuous decision variables, and a more than 500-year horizon. It corresponds to solving a Hamilton–Jacobi–Bellman equation with 10 or 11 state variables. Using our efficient parallel algorithm, we solved it with one specification case in 3.4 wall-clock hours with 102 computer nodes on Blue Waters. Moreover, we have solved the model with many specification cases for analysis. In addition, the largest problem we solved for DSICE used 3,459 computer nodes and took 7.5 wall-clock hours on Blue Waters. Blue Waters allows us to solve these large problems efficiently as has already been shown in our previous work.

PUBLICATIONS & DATA SETS


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