APPLICATION OF LARGE-SCALE COMPUTATION TO OPTIMAL INVESTMENT HEDGING IN ENERGY TECHNOLOGIES

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Overview

Properly positioning ourselves for uncertain climate outcomes, and hedging against uncertain technology mitigation costs, involves solving large scale stochastic dynamic programming problems. Greatly enhanced computing power has become available. For example, the Argonne Leadership Computing Facility has recently installed an IBM Blue Gene P (BG/P) with 160,000 parallel processors. We use this new facility to compute ensembles of energy and climate outcomes and how the distributions shift under various hedging options that could be undertaken over the next ten years.

Methods

Basically, we set up a large scale decision tree with decision nodes and vectors of random outcomes. These random outcomes apply over intervals of time. We represent three periods: The current period until 2020, the medium run until 2035, and the long run stretching out to 2065.

Each random vector of outcomes implies the need to compute a resulting carbon charge conditional on the climate temperature sensitivity and costs of mitigating and adapting to climate change. Climate responses are based on stored reduced-form runs from the large climate models at the National Center for Atmospheric Research (NCAR). Finding the optimal carbon charge in each period for each case is an internal computation sub-problem.

Processes represented include demand for electricity and other energy carriers such as gasoline and diesel fuel and production of these energy carriers. Energy and agriculture related greenhouse gas emissions are calculated. Computer programmers at the University of Chicago’s Computation Institute have written a script to distribute model runs over the large number of parallel processors.

Results

Results show that relatively modest expenditures in the current period for energy research, development, and deployment in technologies that may be needed in future periods, has a large payoff in terms of shifting total social cost distribution downward. In effect these current period hedging expenditures are a robust strategy in view of wide ranging future states of the energy economy and the climate.

The model automatically prints out standard variables such as prices and quantities of electricity and oil, costs of energy resources, costs of alternative energy, and welfare costs measured by consumer surplus changes. The University of Chicago's Computation Institute has developed three dimensional visualization tools to plot probability distributions for the key uncertain outcomes.

Conclusions

Although we view our results as preliminary, we think that the method of setting up formal decision analysis problems under key uncertainties can be insightful. This setup allows one to stretch the range of possible outcomes perhaps more that is normally considered under business-as-usual assumptions plus and minus one standard deviation. Decision analysts often point out that real world uncertainties are often underestimated.

References

Workshop on Modeling Uncertainty in Integrated Assessment Models, University of Chicago, July 2008