Extended Abstract

"A Global Equilibrium Model of Economy-Climate Interactions"

by Per Krusell and Tony Smith

This paper constructs a dynamic general-equilibrium model of the world economy and embeds within it realistic interactions between economic activity and the global climate system. The ultimate purpose of the paper is to provide a quantitative, welfare-based evaluation of government policies designed to reduce emissions of greenhouse gases (such as carbon dioxide) that cause global warming.

The model of the world economy builds on elements drawn from: Dasgupta and Heal's (1974) model of economic growth with a non-renewable resource; models of consumer heterogeneity in the tradition of Bewley (1980), Huggett (1993), and Aiyagari (1994); and models of entrepreneurial risk as in Castro (2005), Covas (2006), and Angeletos (2007). Specifically, the model consists of a continuum of regions corresponding to points (or locations) around the globe. Each region operates a production technology that uses (region-specific) physical capital and carbon energy as essential inputs. Burning carbon to create energy emits carbon (in the form of carbon dioxide) into the atmosphere. Total emissions of carbon across all regions determine the evolution of the global stock of carbon in the atmosphere, and this stock, in turn, influences the global temperature of the atmosphere. The temperature of the atmosphere then influences productive possibilities in each region.

Financial markets are assumed to be incomplete. First, there are no markets for capital: a region can make physical investments only in its own capital stock. Moreover, capital, once installed, is immobile across regions. Second, there are no markets in which regions can insure against idiosyncratic (region-specific) productivity and meteorological shocks. Regions can, however, self-insure by accumulating physical capital and by participating in a worldwide market for risk-free bonds. Regions, therefore, differ ex post for the usual reason: each region experiences a different history of idiosyncratic (uninsurable) shocks. But regions also differ ex ante: each location on the globe has unique geophysical characteristics which determine how it is affected by changes in the global climate.

As the worldwide stock of carbon energy is depleted, this economy approaches a steady state in which aggregate macroeconomic variables grow at constant rates (that depend, as in models of endogenous growth, on parameters describing both preferences and technology) and in which the distribution of capital across regions (appropriately transformed to induce stationarity) replicates itself over time. Because carbon in the atmosphere mixes with the much larger reservoirs of carbon in the upper and (especially) the lower oceans, in this steady state the amount of carbon in the atmosphere does not have disastrous effects on economic activity and human welfare. But because the transition to this steady state occurs over the course of centuries, the recent trend of increasing carbon emissions, should it continue, has the potential to raise the stock of carbon in the atmosphere to alarmingly high levels in the short run.

Characterizing quantitatively the behavior of this global model of economy-climate interactions—and using it to provide detailed quantitative assessments of various climate-related government policies—is a long-term research agenda upon which this paper embarks. The main goal of the current paper is to develop appropriate computational tools and to begin the quantitative analysis.

As an intermediate step to calibrating a version of the economy-climate model with thousands of regions at a high degree of geographic resolution, the paper calibrates first a version in which each region corresponds to a country, with each country being viewed as a price-taker in international financial markets. At this level of aggregation, there exists a wealth of useful information about a wide variety of economic and demographic variables. To calibrate damages from global warming, the paper makes use of the work of Deschenes and Greenstone (2007a, 2007b) and Dell, Olken, and Jones (2008), who relate historical fluctuations in weather to economic outcomes both in particular sectors (such as agriculture) and across entire economies (using panel data for a broad set of rich and poor countries).

The first, and main, task of the paper is to characterize quantitatively the transition of the world economy to a steady state with zero emissions of carbon. This is a difficult problem because the number of state variables (both economic and climatic) is large and because one of these state variables—the distribution over regions—is, in principle, infinite-dimensional. To accomplish this task, the paper exploits the idea of "approximate aggregation" developed in Krusell and Smith (1998), who study aggregate fluctuations in an economy with many consumers.

The second task of the paper is to evaluate quantitatively the size of the global externality associated with emissions of carbon energy. Specifically, what are the distributional effects across regions of implementing the allocation chosen by a benevolent social planner who internalizes the effects of carbon emissions on the global commons of the atmosphere? Relative to the competitive equilibrium allocation, which regions gain and which regions lose, and by how much? To compute constrained-efficient allocations, the paper adapts the methods of Davila, Hong, Krusell, and Ríos-Rull (2005), who perform a similar task for the model in Aiyagari (1994).

Finally, the third task of the paper is to introduce explicit government policies aimed at limiting global warming and its adverse effects, such as taxes on carbon energy or "cap-and-trade" systems that require firms to purchase permits in a competitive market to emit carbon. The paper assesses quantitatively the distributional effects across regions of such government policies, and investigates the extent to which the resulting allocations approximate those that would be chosen by a social planner.

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