Green Growth in the Shadow of a Climate Change Backstop Technology

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Overview

The paper is motivated by the relative scarcity of theoretical research on the near-term macroeconomic implications of future climate change backstop technologies, CCBTs. CCBTs can be defined as cheap, easily scalable technologies that eliminate the disruptive effects of climate change without significant negative externalities. They can work directly by reducing the greenhouse gas emissions to near zero levels, or through various geoengineering options which interfere with the natural mechanisms that transform emissions into climate change. Although CCBTs fitting this definition do not currently exist, these technologies are attractive in theory because their deployment could imply relatively small sacrifices in responding to climate change effectively. In this sense, they are breakthrough technologies. While remaining agnostic about their feasibility or likelihood, I study the implications of such future technology events on efficient consumption, investment and abatement plans using a dynamic macroeconomic model.

There are several real world examples of potential CCBTs. Provided it can be rendered cheap, scalable and negative externality free, nuclear fusion power would qualify. So would fossil fuel power plants fitted with carbon capture and storage technology. Alternatively, any interference with the mechanisms that produce the greenhouse effect on a planetary scale also satisfy the definition. These approaches are known as geoengineering, which IPCC (2012) defines as “methods [that] seek to either (a) reduce the amount of absorbed solar energy in the climate system (Solar Radiation Management) or (b) increase net carbon sinks from the atmosphere at a scale sufficiently large to alter climate (Carbon Dioxide Removal).” While the IPCC discusses several geoengineering proposals, their cost, scalability and the possibility of unintended consequences remain major obstacles.

The paper is related to a literature going back to the seminal papers by Dasgupta and Heal (1974), Hoel (1978), Dasgupta and Stiglitz (1981) which study, among other things, the exogenous and random arrival of a substitute for an essential and exhaustible natural resource. More recently, a number of researchers approach the problem from an endogenous growth perspective, such as Tsur and Zemel (2005) and Valente (2011). The substitution away from fossil fuels is also a key theme in the macroeconomic analysis of climate change. Acemoglu et al (2012), van der Ploeg and Withagen (2012), and Nordhaus (2008) from this literature are closely related to my analysis.

Methods

I study the planner's solution to the standard one-sector growth model modified to isolate three central aspects of the problem. First, I incorporate two-way climate-economy interaction. Economic activity necessarily generates emissions and causes climate change which in turn has negative consequences for economic activity. Second, I introduce abatement which requires an endogenous share of the capital stock but reduces the emissions implied by economic activity. Finally, I postulate a CCBT which relaxes the climate change constraint. The model provides a tractable and theoretically disciplined environment where it is possible to study how the characteristics of the CCBT influence the planner's solution. The CCBT characteristics I am interested in are the technology's arrival date, cost and effectiveness.

Results

My analytical and quantitative results focus on how changes in the CCBT characteristics impact the static production-abatement trade-off and the dynamic consumption-saving trade-off. Consider, for example, two economies which differ only in the effectiveness of the CCBT. How different are the optimal investment profiles in these economies? Alternatively, for a given level of CCBT effectiveness, what are the near term macroeconomic implications of a change in the arrival date of the technology? Is green growth today helped or hindered by such a change that occurs in the future?

My numerical analysis sheds light on these and similar questions. In particular, two broad results emerge. First, to the extent that there is a difference between the constrained and unconstrained steady states corresponding to pre- and post-CCBT phases, the model generates rich dynamics in key macroeconomic variables. Optimal investment and consumption profiles, for example, appear particularly sensitive to the explicit modeling of the CCBT. Second, changes in the characteristics of CCBT can have significant macroeconomic implications several periods before the technology actually arrives. These results are primarily driven by the consumption smoothing motive of the social planner.

Conclusions

The main contribution of the paper is to (re)introduce the concept of breakthrough backstop technologies into macroeconomic analysis of climate change. Breakthrough technologies were an important element in several influential studies published in the 1970s. However, most recent papers in the field treat the problem as one of gradually reducing exhaustible fossil fuel use by switching to currently available, albeit costly, substitutes. While this line of inquiry is valid and informative, a comprehensive analysis requires a broader definition of backstop technologies in the climate change context and, as the paper demonstrates, uncovers subtle but significant insights.

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