EVALUATING CARBON CAPTURE AND STORAGE IN A CLIMATE MODEL WITH ENDOGENOUS TECHNICAL CHANGE

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Overview

In this paper, we wish to assess the scope for CCS and CCS R&D as part of a socially efficient solution to the climate change problem. The vehicle that we use for this purpose is the intertemporal model of climate and directed technical change developed by Acemoglu, Aghion, Bursztyn and Hemous (2012, AABH hereafter). In this model, final good production requires two inputs, fossil fuel and non-fossil fuel energy. Both types of energy are produced using labor and capital with the help of the latest available technologies. Technological development result from costly R&D efforts. Given a finite number of scientists, faster technological progress in one sector needs to be balanced against slower progress in the other sector. The production of fossil fuel energy increases the stock of CO_2 in the atmosphere, and therefore contributes to a global increase in temperature. The global warming, in turn, reduces the quality of the environment and with it the welfare of the society.

To this model, we append a new sector, that for CCS, which also operates using labor and capital. Similar to the two energy sectors, the CCS technology may be improved by devoting resources to R&D. After calibrating our model using data on world energy production levels and estimates of the marginal cost of CCS, we ask ourselves whether it is socially optimal to include CCS in today's or the near future's mitigation portfolio; and to devote R&D resources to improve CCS technology, such that it becomes part of an optimal mitigation policy in the more distant future.

Surprisingly, we find that even for optimistic cost estimates available for CCS it is not optimal to deploy CCS or devote resources to R&D in CCS technology either in the near or distant future. We trace these results back to the model's implied production structure for knowledge.

Methods

We calculate the welfare-maximizing allocation numerically. To implement the model numerically, we proceed as in AABH. In estimating the average cost of CCS, we make use of Finkenrath (2011) where the average estimates for the relative increase in levelised cost of electricity for various CO_2 capture methods are presented. We supplement the discussion of the numerical results with analytical derivations.

Results

We find that for an optimistic cost estimate available for CCS ($58/ton of CO_2 avoided) it is not optimal to deploy CCS or devote resources to R&D in CCS technology either in the near or distant future. We ask by how much the marginal cost of CCS needs to fall such that both CCS and R&D into the CCS technology become socially optimal. Surprisingly, we find that the decrease in the cost of CCS must be quite large, at least 56% of the average current estimates.

Potential significance

Addressing climate policy requires a long-term perspective where technological change plays a significant role. In this regard, our paper purposefully builds on the recent literature on endogenous technical change (see Acemoglu, 2002, 2003). The idea is to look at the role of technical change in avoiding an environmental disaster and attaining a long-run growth rate, which is set at 2% (cf Jones, 2015, Table 2). We take the value of the elasticity of substitution between the clean and dirty carriers as 3 (van der Zwaan et al., 2002; Gerlagh and van der Zwaan, 2003, 2004; Acemoglu et al., 2012).

The fact the clean and dirty energy are good substitutes induces a non-convex input relationship between the productivities of the clean sector and dirty sector (possibly complemented with CCS) in the determination of the economy's overall productivity index. This means that the allocation of R&D resources is characterized by corner solutions and that changes in the nature of the solution only come about by large changes in policy and/or cost parameters. Thus, with the rising carbon tax, the clean strategy, which relies on clean carriers, will be preferred and allow for a long run growth rate that is twice as large. The use of a lower discount rate and allowing for higher environmental sensitivity (e.g., a lower carbon cap) both favor the clean strategy. For both CCS and R&D into the CCS technology to become socially optimal, we find that the decrease in the cost of CCS must be quite large, at least 56% of the average current estimates. For the sufficiently low cost of CCS, the gradual use and development of CSS technology allows for a higher consumption level in the medium run at the cost of higher temperature rise. Nevertheless, this leads to a long run growth rate that is half of that for the clean strategy.

To the best of our knowledge, only Grimaud and Rouge (2014) draw attention to the adverse effects that CCS policies can have on the long-run growth rate. Nevertheless, there is no endogenous technical change in their model. Furthermore, the fact that the clean strategy becomes superior when more weight is attached to the environment (e.g., choosing a lower ceiling on the accumulated atmospheric CO_2, which represents a threshold beyond which a catastrophe takes place, Moreaux and Withagen, 2015), explains why our results differ from the literature studying the desirability of CCS.

Conclusions

In recent decades, carbon capture and storage has been considered as a promising strategy to curb CO_2 emissions and therefore to address the problem of global warming. Given the infancy of CCS technology, and the need for further research, development and demonstration, it is desirable to assess the optimality of this strategy not only on the basis of its current marginal cost, but also on the potential for improvements in cost efficiencies following R&D efforts in dirty energy, clean energy, and CCS sectors. We find that even for very optimistic estimates for the current marginal cost of CCS ($\$58/tCO_2$), it is not optimal in either the near or the distant future to deploy this abatement technology and dedicate research efforts to it. It is only when we consider current marginal costs less than about 50% of the optimistic reference level, that a regime with CCS and R&D of CCS technology becomes optimal, but even then not in the near future. We also observe that a more stringent environmental constraint (in the form of lower disaster temperature rise) limits the scope for the CCS sector and the corresponding R&D activity.

References

Acemoglu, D. (2002). Directed technical change. *The Review of Economic Studies 69*(4), 781–809.

Acemoglu, D. (2003). Labor- and capital-augmenting technical change. *Journal of the European Economic Association 1*(1), 1–37.

Acemoglu, D., P. Aghion, L. Bursztyn, and D. Hémous (2012). The environment and directed technical change. *American Economic Review 102*(1), 131–166.

Finkenrath, M. (2011). Cost and performane of carbon dioxide capture from power generation. *International Energy Agency Working Paper,*.

Gerlagh, R. and B. van der Zwaan (2003). Gross world product and consumption in a global warming model with endogenous technological change. *Resource and Energy Economics 25*(1), 35–57.

Gerlagh, R. and B. van der Zwaan (2004). A sensitivity analysis of timing and costs of greenhouse gas emission reductions. *Climatic Change, 65*(1-2), 39–71.

Grimaud, A. and L. Rouge (2014). Carbon sequestration, economic policies and growth. *Resource and Energy Economics 36*(2), 307–331.

Jones, C. I. (2015). The facts of economic growth. *NBER Working Paper 21142*.

Moreaux, M. and C. Withagen (2015). Optimal abatement of carbon emission flows. *Journal of Environmental Economics and Management 74*, 55–70.

Papageorgiou, C., M. Saam, and P. Schulte (2016). Substitution between clean and dirty energy inputs - a macroeconomic perspective. *Review of Economics and Statistics* (forthcoming).

van der Zwaan, B., R. Gerlagh, L. Schrattenholzer, et al. (2002). Endogenous technological change in climate change modelling. *Energy Economics 24*(1), 1–19.