Kick-starting the green innovation machine

Philippe Aghion David Hemous Reinhilde Veugelers
9 December 2009

Mitigating climate change while maintaining economic growth will require a wide portfolio of technologies. This column says too little has been done to turn on the "green innovation machine". It says governments in developed economies should price carbon, subsidise research, and facilitate technology transfer to developing countries.

The reality of climate change is no longer a contentious issue. The debate concerns the growth consequences of climate-change containment. Economists have not tackled this debate very well, largely disregarding the innovation factor by ignoring the fact that the portfolio of technologies available tomorrow to adapt to and mitigate climate change depends on what is done today.

Technology is the key

Recent economic simulations (e.g. Bosetti *et al* 2009) suggest that technology will be the key. To keep the costs of mitigation and adaptation manageable while maintaining reasonable economic growth, we need to put into operation a sufficiently wide portfolio of technologies. "Backstop technologies" – those that are zero-emission and not dependent on constrained resources – are particularly important for dealing with the longer-term and worst-case scenarios of climate change. These technologies are not yet available or still far from commercialisation.

Unfortunately, too little has been done so far to turn on the "green innovation machine". In Aghion, Veugelers, and Serre (2009), we take a look at the recent performance of the private green innovation machine. The available empirical evidence is disappointing. Despite a recent spurt, only 2% of total patents applied for worldwide are environment-related (2001-2006). Japan is the clearest positive outlier, holding 35% of all environmental patents; the US accounts for "only" 15%. And when it comes to the diffusion and adoption of green technologies, little is happening. This is particularly (but not exclusively) true in the field of electricity generation and distribution, the business sector accounting for the highest level of CO2 emissions.

New insights for the green policy agenda

The private green innovation machine is not up to the challenge. It needs government intervention to address a combination of environmental and knowledge externalities. Economists have long emphasised the importance of carbon prices as policy instrument to use. Properly factoring in *directed* technological change, i.e. taking into account that research will be directed to the most profitable projects, delivers new insights for the green policy agenda. Building on an endogenous growth model on innovation and environment developed by Acemoglu, Aghion, Bursztyn, and Hemous (2009), we discuss how government intervention should be designed to effectively turn on the private green innovation machine and, more generally, to fight climate

change at the lowest possible cost for growth.

Researchers choosing to direct their innovation activities at improving either clean or dirty technologies will typically target innovation towards the most profitable sector, taking into account the current state of technology in both sectors and government taxes and subsidies. In this directed-innovation perspective, governments need to address not only the standard environmental externality but also imperfections in the research sector, particularly those whereby past advances in old, dirty technologies make future production and innovation in clean sectors relatively less profitable. This introduces a new cost-benefit analysis to policy intervention. The cost of supporting the cleaner technology is slower economic growth while innovation switches from the more technologically advanced dirty sector to the technologically immature clean sector. These costs will be born initially. It will take a certain period before these losses will be recovered through their benefits in the form of higher and cleaner growth, once the clean sector is innovating.

Factoring in directed innovation will change our assessment of

- the costs of delaying policy intervention,
- the optimal mix of policy instruments required for efficiently fighting climate change, and
- the terms of a global policy dialog and coordination between developed and developing countries.

The cost of delaying policy intervention

Factoring in directed technical change reinforces the case for immediate intervention. Delaying intervention not only leads to further deterioration of the environment, it allows dirty innovation to continue to outpace clean innovation, widening the gap between dirty and clean technology. That lengthens the time required for clean technologies to catch up to and replace dirty technologies. As this catching-up period is characterised by slower growth, the costs of delaying intervention, in terms of foregone growth, will be higher.

Calibrations from the Acemoglu, Aghion, Bursztyn and Hemous (2009) model show the cost of delaying intervention, computed as the "lost" consumption in each period expressed as a percentage of the level of consumption which would result from "best-timed" policy intervention, can amount to 6% for a delay of 10 years and a discount rate of 1%.

Instruments for green intervention: Carbon prices and directed research subsidies

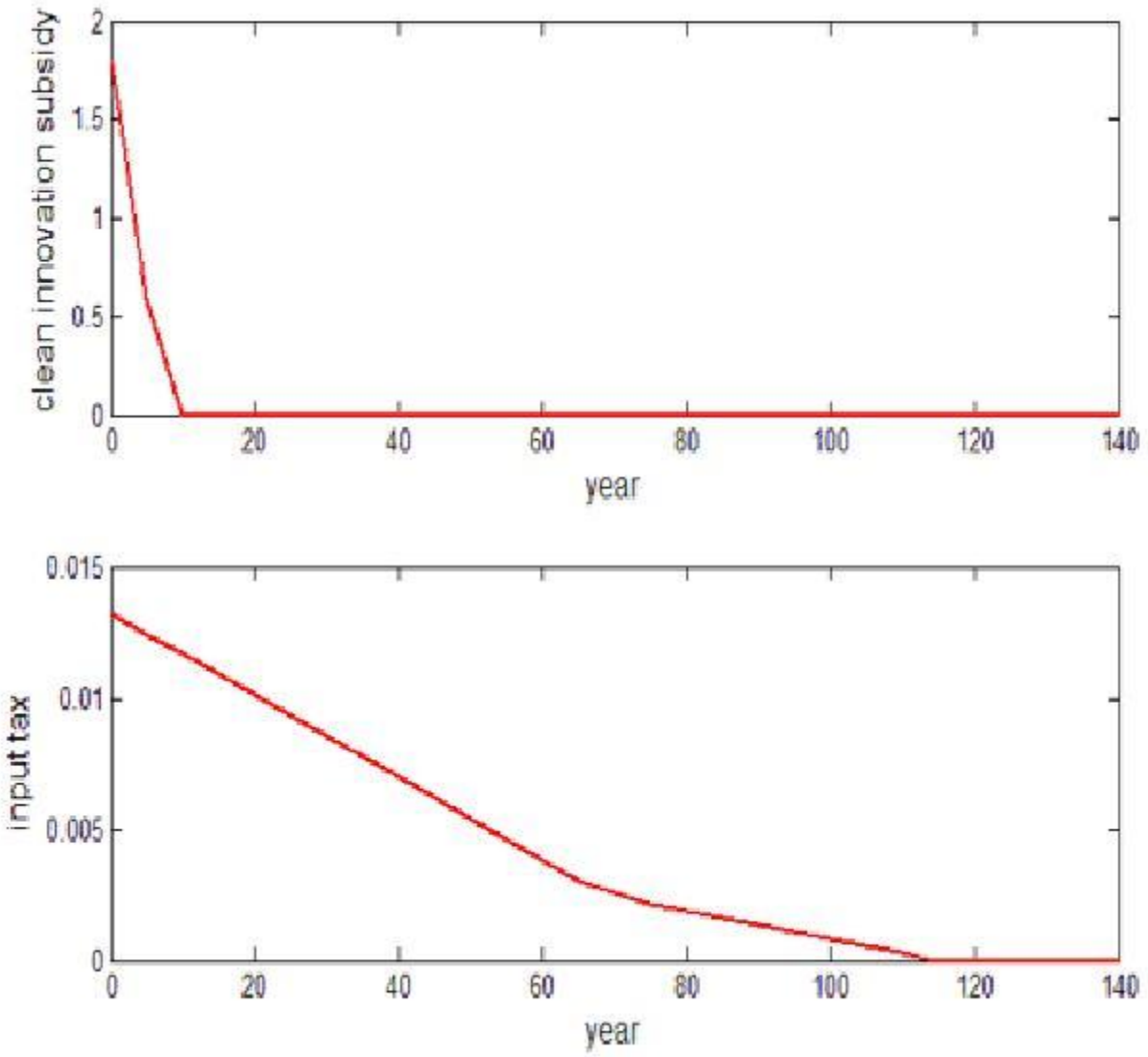
The Acemoglu, Aghion, Bursztyn and Hemous (2009) model shows that the *optima*l policy involves using (i) a carbon price, an input tax (or cap–and-trade policy), on dirty technologies to deal with the environmental externality; *and* (ii) direct subsidies to clean R&D (or a profit tax on dirty technologies) to deal with the knowledge externality. Relying on the carbon price alone leads to excessive consumption reduction in the short run and would therefore be a more "costly" policy scenario. And because the two-instrument policy reduces the short-run cost in terms of foregone short-run consumption, it reinforces the case for immediate implementation even for

values of the discount rate under which standard models would suggest to delay implementation.

Calibrations show that the cost of using only a carbon tax instead of the combination between a carbon tax and a subsidy to clean R&D, can amount to 1.33% for a discount rate of 1%. This cost is again expressed as the percentage of reduced consumption every period from the optimal policy equivalent.

The good news is that government intervention (pricing carbon and subsidising clean technologies) can be reduced over time. Figure 1 shows that (i) subsidies for new clean technologies should be allocated immediately but can be quickly reduced as soon as innovation has taken off for these technologies and (ii) the carbon price can decrease over time. With the emergence of perfectly clean backstop technologies that have zero emissions and with the innovation gap between clean and dirty technologies eliminated and the stock of past emissions diminishing, the environmental externality gradually disappears, thus reducing the need for a carbon price over time. Unfortunately, totally clean technologies will take time to become available, which in turn implies deferring the phasing out of carbon pricing.

Figure 1. Phasing out green intervention



Source: Calibrations from the Acemoglu, Aghion, Bursztyn and Hemous (2009) model.

Results are for a discount rate of 1.5%. Taxes and subsidies are proportional. Scales should be read as follows: for input taxes 0.015 reflects a tax of 1.5% on the price of the dirty input; for subsidies 1.5 reflects a 150% subsidy to profits derived from clean technologies

Developed countries should smooth access to clean technologies for developing countries

At the heart of the current environmental debate in the run up to Copenhagen is the issue of how to organise the international coordination of policy interventions. What if other countries are not intervening to support a switch to clean technologies? Does it still pay to intervene unilaterally? This holds particularly with respect to the developed countries' commitment being made conditional on the engagement of large emerging countries like China, India, and others.

Factoring in a directed technological change brings new light on how should debate and

negotiate on the implementation of a global environmental policy. First, the transfer of clean technology from more to less advanced countries deserves consideration. While some emerging economies, like China or Brazil, are part of the global innovation machine, most of the "South" can at best only imitate/adopt green technologies previously invented in the developed countries.

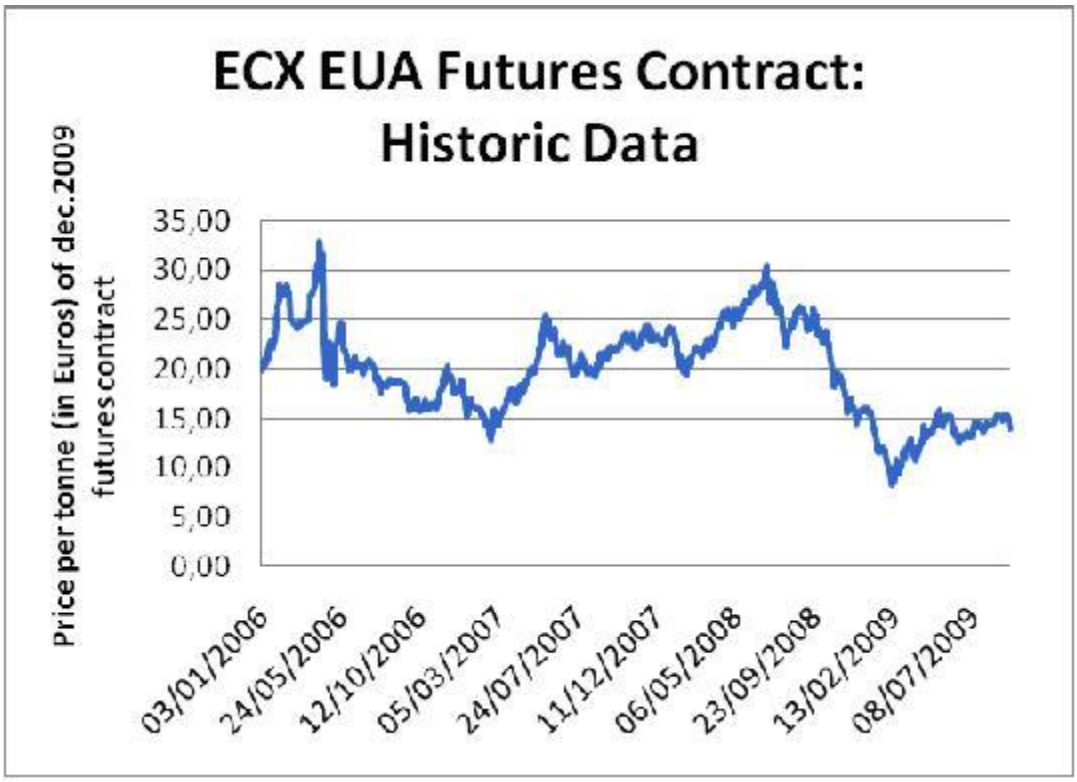
Developed countries directing their own technical change towards clean technologies and then facilitating the diffusion of new clean technologies would go a long way towards overcoming global climate change. In particular, it may not be necessary to tax dirty input production in the "South" in order to avoid a global environmental disaster; unilateral government intervention in developed countries would turn on the green innovation machine there, which would activate the green "imitation" machine in the "South" to adopt cleaner technologies developed elsewhere. The higher the spillovers from the developed green innovation machine to the developing green imitation machine, the more active the green "imitation" machine in the "South". This makes a case for unilateral policy intervention by the developed countries even if the developing countries will not take any actions, greater technology transfer, and improved absorptive capacity in developing economies.

Factoring in trade introduces a more cautious stance on unilateral climate change actions. In a free trade world, having a country or region adopt unilateral environmental policies by taxing its dirty technologies, might create a pollution haven effect in other countries or regions (de Melo, Grether, and Mathys 2009). We should prevent such perverse effects by making clean technologies available and affordable to all countries worldwide. Once clean technologies are made available to all countries at low cost, carbon tariffs (or the threat of them) may come into play to prevent countries from specialising in large-scale production and export of dirty goods, which would defeat the whole purpose of the unilateral environmental policies.

Are governments currently deploying the right policies?

We examine in detail the record of green government policies and conclude that we are still a long way off. Overall, public budgets for climate change R&D are very low, with only a few promising signs coming very recently. These low budgets come on top of the lack of clear long-term consistent *price for carbon*. Environmental taxes in the EU27 averaged a mere 6.4% of total tax revenues in 2006. In addition, there is high dispersion in the level of carbon taxes across EU countries, thus jeopardising their effectiveness. At EU level, the first phases of the EU's Emissions Trading Scheme have established a carbon market, but the carbon price is low and volatile. The carbon price, as measured on the ECX EUA Futures Contracts, reached their highest level of €32.90 in April 2006 but were only €8.20 in February 2009.

Figure 2. The EU price of carbon



Source: ECX Historical Contracts Data (Daily Futures, Futures & Options)

Long-term consistency is particularly important for the carbon price to serve as an incentive for green innovations. The US and other major emitting countries are even further away than the EU from establishing an innovation-inducing carbon price. And the limited evidence available suggests that insufficient action is being taken with regard to technology transfer to developing countries. Although the Clean Development Mechanism framework was designed to trigger technology transfer, only a limited number of these projects in fact involve technology transfer.

Although past evidence on green private R&D and innovations showed low activities and not much dynamics, there seems to be a momentum being created more recently, most clearly observed in the market for clean-tech venture capital. Deloitte's 2009 survey on Global Trends in Venture Capital reports that, despite the crisis, 63% of surveyed venture capitalists anticipate an increase in their investment in clean-tech, the highest percentage among all sectors considered. But as this optimism of venture capitalists seems to be based on anticipated government support for clean-tech, are we merely looking at a bubble that will collapse when governments do not get their green policies right?

References

Acemoglu, D., P. Aghion, L. Bursztyn, and D. Hemous (2009), "The environment and directed technological change," NBER Working Paper 15451.

Aghion, P., D. Hemous and R. Veugelers (2009), "No green growth without Innovation",

Bruegel Policy Brief, 2009/07, Bruegel Brussels.

Aghion, P., R. Veugelers and C. Serre (2009), "Cold Start for the Green Innovation Machine", Bruegel Policy Contribution, 2009/12, Bruegel, Brussels.

Bosetti, V., Carraro, C. Duval, R. Sgobbi, A. and M. Tavoni (2009), "The Role of R&D and Technology Diffusion in Climate Change mitigation: new perspectives using the WITCH model", OECD, Economics Department Working Paper 664.

De Melo, J., J-M. Grether, and N. Mathys (2009), "Trade, pollution, and the environment: New international evidence", VoxEU.org, 28 November.

Deloitte (2009), "Global Trends in Venture Capital 2009 Global Report".

Helm, D. and C. Hepburn (2009), *The economics and politics of climate change*, Oxford University Press.