

No green growth without innovation

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1. The importance of innovation for climate change

With the reality of climate change no longer a contentious issue, the debate has shifted towards the growth consequences of climate change containment. Recent economic simulations confirm that, in order to keep the costs of mitigation and adaptation manageable and to safeguard reasonable levels of economic growth, we need to put into operation a sufficiently wide portfolio of technologies. Although much can be done if already existing technologies are diffused, new technologies also need to become available, particularly backstop technologies that are zero-emission and not dependent on constrained resources. These radical technologies are particularly important for dealing with the longer-term and larger-effects scenarios. 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 a recently published Bruegel Policy Contribution, Aghion, Veugelers and Serre (2009) take a look at the recent performance of the private green innovation machine. The available empirical evidence is disappointing. For instance, despite a recent spurt, WIPO data show that only 2.15 percent of total patents applied for worldwide are environment-related (2001-2006). If we look at which countries are active in patenting environmental technologies, Japan is the clearest positive outlier, with 35% of world ‘green patents’. Korea and China also specialise in environmental patents. The US, despite its 15% share of world ‘green patents’, is least specialised in environmental technologies. In Europe, Germany, with a share of 8%, is by far the largest country for environmental patents, being specialised in environmental technology. The UK has a low profile in environmental technologies.

Also with regard to the diffusion and adoption of green technologies, (too) little is happening, particularly (but not exclusively) in the field of electricity generation and distribution, the business sector accounting for the highest level of CO₂ emissions. The latest R&D scoreboard data for 2009 (European Commission, IPTS) confirm the weak R&D picture for the electricity sector. For the EU, the ‘electricity sector’ has 15 companies in the list of top EU1000 R&D spenders. These companies have an average R&D-to-sales ratio of only 1.3%. Of these 15 companies, only 2 (French)

companies make it in the 100 largest R&D spenders in the EU (Areva, EdF). Six companies from the alternative energy sector managed to get into the 2009 JRC-IPTS Scoreboard as being among the 1000 largest R&D spenders in the EU. Together they represent €324m in R&D expenditures, or 0.25 percent of total R&D spending by the 1000 largest EU R&D spenders. By far the largest company of these six is Vestas Wind from Denmark; the 5 others are smaller German companies.

2. Policies directing innovations for green growth

Facing a combination of environmental and knowledge externalities, the private green innovation machine cannot be expected to be effective on its own. It needs government intervention. In a recently published Bruegel Policy Brief, Aghion, Hemous and Veugelers (2009) discuss how this government intervention should be designed in order to effectively turn on the private green innovation machine, and more generally to fight climate change, at the lowest possible cost for growth. Using a growth model of innovation and environment, developed by Acemoglu, Aghion, Bursztyn and Hemous (published as a NBER Working Paper in 2009), which takes into account that research will be directed to its most profitable applications, new insights are obtained on what the optimal timing, speed and instruments of intervention should be. In particular our analysis suggests some game-changing principles that should guide climate-change policies.

- *A public-private partnership is indispensable:* Government intervention should leverage the private green innovation machine, not replace it. Private market forces need to be mobilised and redirected towards cleaner energy sources by governments.
- *We must act now:* Government intervention should start as soon as possible, thereby minimising the costs of delay. Even for very low discount rates, delaying policies that would redirect innovation towards clean energy sectors and activities, will result in much higher costs in the future.
- *A portfolio of instruments is needed including simultaneously carbon prices and R&D subsidies:* A price for carbon to provide an incentive for carbon-saving investments is obtained most clearly through a carbon tax, provided the tax rate is set sufficiently high and is predictable in the long term. A cap-and-trade system can achieve the same result as a tax but requires a considerable amount of information and expertise to get the emission-allocation process right, creating more room for error and exposure to political pressure. In tandem with a sufficiently high and stable carbon price, R&D support for clean technologies is needed.

Of course, one could always argue that to some extent a carbon price on its own could do the trick (discouraging the use of dirty technologies also discourages innovation in dirty technologies). However, relying on the carbon price alone leads to excessive consumption reduction in the short run, and would therefore be a more 'costly' policy scenario.

Also removing non-market barriers, easing the substitution from dirty to green technologies (regulatory restrictions, standards, access to the grid...) is an important government policy lever. The effectiveness of environmental subsidies and taxes are raised when clean technologies more easily substitutes for the dirty ones.

- *Intervention does not need to be permanent:* Government intervention is crucial at earlier stages, but market forces can perform a large part of the job of reallocating production and innovation activities towards clean sectors, provided they are given the right incentives. Government should have an exit strategy for its interventions, particularly for subsidies to specific technologies, as soon as the private innovation machine for these technologies is self-supporting.

What do these principles mean for a green innovation policy in practice? In light of our discussion, it would mean:

- (i) to introduce a carbon price together with green R&D subsidies right away;
- (ii) this carbon price should be at an initially high enough level, but it can decrease over time as substitution technologies become progressively on track;
- (iii) to make the access of existing cleaner technologies (e.g those pioneered by Japan and other countries that were first to invest in clean innovations) as broad and cheap as possible; In the short term when we are still anticipating better technological alternatives to be available in the future, support schemes for currently available technologies should be designed time-consistently to avoid creating too big gaps to bridge for new, more radically clean technologies still in the pipeline;
- (iv) As more advanced backstop technologies are unlikely to be available before 2020, the temporary use and support of transition technologies, need to be factored in. Particularly interesting candidates for transition technologies are those for which the transition or substitution from dirty technologies can be made at lower costs (like Carbon Capture and Storage). In any case, support for transition technologies should be temporarily, switching to other radically cleaner technologies as soon as viable
- (v) substantive early stage deployment support to help bring new clean technologies to the market and neutralize the installed base advantage of the older, dirtier technologies. As it will take time for more radically clean technologies to be developed and to be available and adopted on the market, this further justifies an early start to government support for these technologies and warns against using too strict time targets for reaching CO2 reductions, as this favors existing somewhat cleaner technologies relative to new more radically cleaner technologies.

At the heart of the current environmental debate in Copenhagen, is the issue of how to organize the international coordination of policy intervention. As the benefits of reductions in CO2 emissions will be global, this sets the scene for countries engaging in classic free-riding, avoiding the costs of interventions. What if other countries are not intervening to support a switch to clean technologies? Does it still pay to intervene unilaterally? Is it good policy to make actions conditional on the level of

other countries' commitments? Factoring in directed technological change brings new light on how developed and developing countries should debate and negotiate on the implementation of a global environmental policy

While some of the emerging countries, like China or Brazil, are becoming part of the global innovation machine, most of the "South", particularly the poorest "South" at best can only imitate/adopt green technologies previously invented in the developed countries when available at low cost. This implies that by having the developed countries directing their own technical change towards clean technologies and by then **facilitating the diffusion of new clean technologies**, one can go a long way towards overcoming global CC. In particular, it may not be necessary to price dirty input production in the "South" in order to avoid a global environmental disaster: unilateral government intervention in developed countries will turn on the green "innovation" machine in the "North", which then will set in motion the green "imitation" machine in the "South" to adopt cleaner technologies developed in the "North". The higher the spillovers from the developed green innovation machine to the developing green imitation machine, the more active the "imitation" machine in the "South" to implement clean technologies rather than dirty ones. This makes a case for unilateral policy intervention by the developed countries, even if the developing countries would not take any actions. It also makes a case to ease the technology transfers from the "North" to the "South" and to improve their capacity to effectively absorb Northern technology. Only once clean technologies are made available to all countries at low cost may carbon tariffs, or the threat of them, come into play to prevent countries from reacting to unilateral environmental policies by developed countries by specialising in large-scale production and then export of dirty goods (the so-called 'pollution-haven' or 'carbon-leakage' effect).

3. Do we have what it takes?

Are we currently deploying the right policies? The Bruegel Policy Contribution by Aghion, Veugelers and Serre (2009) examine in detail the record of government policies and conclude that we still have a long way to go. On carbon prices, the evidence shows not only the low level of carbon taxes in most EU member states, but there is also a high dispersion in carbon taxes across EU countries. At EU level, the first phases of the European Union's Emission Trading Scheme (ETS) established a carbon market, but at low and volatile levels. Beyond the discussion on whether current taxes and cap-and-trade systems in place generate a sufficiently high carbon price to induce green innovations, there is clearly an issue of the carbon price being far from long-term predictable. It is particularly this latter feature that is important as it serves as an incentive for green innovations. On subsidies to green R&D, again the evidence shows the poor performance of the major policy actors. Public R&D spending targeted to environment and energy efficiency is a very minor share of total public R&D spending. Not only are the public budgets for such R&D very low, they are not increasing over time. Only *very* recently have some more promising signs of increased public R&D budgets been observed.

On **technology transfer** to the developing countries, the limited evidence suggests also on this front too little is going on. Although the UN's Clean Development Mechanism framework was designed to stimulate technology transfer, only a limited number of projects involve technology transfer.

4. How to move forward

With signs, particularly from the venture capital market, that the private green innovation machine is ready to take off but waiting for the push from government, the momentum should not be wasted by policymakers. While member states are pivotal, particularly on supporting new clean technologies, the EU also has important levers:

- A first key objective of EU policy should be to ensure that the price of carbon is stable and set at the desired level. This involves improving the incentivising effect of the European cap-and-trade system, ensuring that the mechanism generates a sufficiently high and long term predictable carbon price. In addition, to ensure an EU-wide integrated carbon price, the EU should also play a more active role in coordinating the carbon tax policies of individual EU member states.
- The EU should stimulate the research and commercialisation of new, breakthrough technologies by increasing the public funding of green basic R&D, through the EU's R&D Framework Programme and other funding. It can also improve coordination of research programmes for climate change among EU Member States and with non-EU partners.
- The EU should coordinate on clear and time-consistent green regulations, standard- setting and public procurement among member states, ensuring a large, integrated EU output market for green investments.
- Competition policy and internal-market instruments should also be used to ensure a more integrated and contestable EU-wide electricity generation and distribution market which is keener to absorb new, cleaner technologies.
- The EU should take a leading role in international coordination of climate-change action by developing a roadmap for an international cap-and-trade system, or at least international linkage of the cap-and-trade systems of major players, in particular the US. This would include removing barriers to trading permits across different systems.
- The EU should advocate and promote the development of an equitable financing scheme for climate-change action by less-developed countries and by improving their access to current and future green technologies developed in the EU.