S4-2 Modelling Innovation and Technology Diffusion: Implications for Policy Action

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In order to meet climate change mitigation targets, significant changes in technological portfolio are needed. However, low or zero carbon technologies currently have a limited range of application and energy related R&D has declined during the past two decades. It is thus extremely important to revert this trend with a boost of R&D spending to increase energy efficiency and to invent carbon free energy technologies.

The policy questions are then the following: how to induce and manage a rapid increase in energy related R&D? Do we need specific R&D policies coupled to mitigation policy?

If we assume a stylized world in which a global climate policy to stabilize Greenhouse Gases (GHG) in the atmosphere at the end of the century is implemented by means of a global cap&trade regime, the international price of carbon is a first indicator of how severe the mitigation effort is and how much innovation is needed.

Scenarios developed using the Integrated Assessment Model WITCH (Bosetti et al 2006, Bosetti, Massetti and Tavoni, 2007; Bosetti et al 2009) consistently show that a price signal alone is sufficient to trigger a sharp increase in energy-related R&D spending. This is especially true for more stringent climate policy, since marginal abatement costs are non-linear in the amount of abatement effort.

Energy efficiency improvements are necessary to achieve any stabilization target. For low stabilization targets however, they are not sufficient. Breakthrough technologies to decarbonize the energy sector and the transport sector have to be invented and deployed if very low concentrations levels have to be reached at the end of the century (Bosetti et al, 2009a, 2009b). Scenarios developed using the WITCH model show that the potential savings of breakthrough technologies are high and motivate a much higher spending then energy efficiency R&D alone. In particular, it can be shown that, in order to deploy breakthrough technologies by mid-century, it is necessary to start investing in R&D as soon as possible.

This rapid increase in energy R&D investments raises some concern. It is in fact feared by many that the incremental spending in R&D in the energy sector will mainly come at the cost of R&D investments in other sectors. Energy R&D, by crowding-out other forms of R&D, would then reduce technological progress in other sectors. The benefits of energy related technological innovation would then be lower than what is commonly perceived.

A version of the WITCH model which displays two knowledge stocks, one to increase the productivity of the energy input and the other to increase the productivity of the capital-labor input, has been used to study the true-macroeconomic costs of R&D spending under climate policy (Carraro, Massetti and Nicita, 2009a). Numerical and analytical results show that it is only in the short run that there exist tensions between the energy and non-energy R&D sectors. In the long-run it is instead reasonable to assume that societies will be able to adjust to higher R&D spending in the energy sector by expanding total R&D investments. However, it appears that this is not needed. A low-carbon world is in fact probably going to be a world with a lower rate of technological innovation (i.e. with lower overall R&D spending). This is explained by a contraction of the economic activity in non-energy sectors caused by climate policy.

A major policy question is whether specific policies to support R&D in energy related sectors are needed. Support to R&D investments, especially in the form of subsidies, has been frequently advocated. The major reason to support R&D activities are the well-known knowledge market failures.

The WITCH model has been equipped to study knowledge market externalities both at domestic and international level (Bosetti et al 2008; Carraro, Massetti and Nicita, 2009b). While international spillovers in the creation of new knowledge in the energy sector appear to be modest and do not motivate the creation of a special international Fund to subsidize research, domestic spillovers are much stronger. It is still not clear how domestic policies to spur innovation and climate policy could be tuned to deliver the most desirable outcome, but preliminary results show that R&D policies to solve domestic market failures, if coupled with climate policy, would cause a global increase of R&D investments, contrary to what found when domestic externalities are not internalized.

Technological innovation as a “stand alone” policy, without any constraint on emissions, is not going to solve the climate problem. Lower carbon intensities are achievable, but overall emissions do not go even close to the necessary long term target. If domestic externalities are fully internalized, it is also possible that overall emissions increase, driven by rebound effects.

In conclusion, long-term, credible, carbon price signals are probably sufficient to stimulate long-run technological progress and R&D spending to increase energy efficiency and to de-carbonize the economies. To this end, credible climate policies are the most needed determinant of technological innovation. Breakthrough technologies will be crucial to decarbonize the transport sector and need a substantial amount of R&D investments from the very beginning of the mitigation effort. Pressures on the R&D market do not seem a major issue, at least in the long run. The contribution of a global fund to sponsor R&D spending has a limited role. Domestic policies to reduce knowledge externalities appear instead to have a greater potential. R&D policy alone is instead not a policy option to tackle climate change.

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