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On the selection of financing instruments to push the development of new technologies: Application to clean energy technologies

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ABSTRACT

Achieving climate policy goals requires mobilizing public funds to bring still immature clean technologies to competitiveness and create new technological options. The format of direct public support must be tailored to the characteristics of technologies addressed. Based on the experience accumulated with innovation programs, we have identified those features of innovation that should directly condition the choice of direct support instruments. These include the funding gap between the cost of innovation activities and the amount of private funds leveraged; the ability of technologies targeted to compete for public funds in the market; the probability that these technologies fail to reach the market; and the type of entity best suited to conduct these activities.

Clean innovation features are matched to those of direct support instruments to provide recommendations on the use to be made of each type of instrument. Given the large financing gap of most clean energy innovation projects, public grants and contracts should finance a large part of clean pre-deployment innovation. However, public loans, equity investments, prizes and tax credits or rebates can successfully support certain innovation processes at a lower public cost. Principles derived are applied to identify the instrument best suited to a case example.

1. Introduction

This article provides guidelines for the selection of policy instruments directly mobilizing public funds to push the development of new technologies. These general guidelines are then used to provide specific recommendations for clean energy technologies. The focus of our analysis is on the support of *pre-deployment* innovation, i.e., the first and highly risky stage of the innovation chain. "Getting the market prices right" is necessary to trigger clean energy innovation, as argued by Popp (2002). However, this alone will not result in an adequate and efficient transition to a low-carbon (low-C) economy, see Foxon (2003). It is actually a combination of technology push policies and demand pull ones which could succeed in avoiding serious climate damage at an affordable cost. According to Arrow (1962), two main factors are responsible for the reduction observed in the level of privately financed clean Research, Development, and Demonstration (RD&D) activities below optimal levels:

- The existing limits to the share of market revenues from the exploitation of new technologies that innovators can appropriate (which, as explained below, may be especially low for clean innovation);
- and the unwillingness of the latter to bear innovation risks.

Other barriers to achieving an optimal level of innovation delivered by the market are the externalities not properly addressed (like the environmental one created by Green House Gas (GHG) emissions) and the lack of knowledge of the benefits that innovation will ultimately deliver, see Stoneman (1987). Barber and White (1987) point out to the difficulties for private investors to internalize the long term dynamic benefits of innovation (and clean innovation is long term and dynamic). Relative support needs decrease with proximity of the innovation activities to the market (since risks decrease as well). However, overall investments needed increase. Then, in the case of clean innovation, the total amount of public funds needed in development and demonstration may actually increase with respect to early research stages, see Grubb (2003).

Climate policies currently implemented are unlikely to avoid environmental disaster, see IEA (2010). Taking the lead, the European Union (EU) has committed to reduce its CO_2 emissions

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by 80% by 2050 compared to 1990 levels. Meeting this objective requires using at large scale a large number of low-C technologies, much of which are not yet competitive (nor even technically proven). Clean RD&D activities within the EU and elsewhere will need to increase significantly in order to develop new clean technologies and bring existing ones to competitiveness.

Current carbon prices are not high enough. What is more, prices in the future are not deemed to follow a stable and adequate path, see Aghion et al. (2009). Adequate carbon prices should provide strong enough incentives for private parties to make use of clean energy technologies. However, other existing market failures, if not addressed, would tilt the balance in favor of already existing, close to the market, clean technologies. A major market failure is that RD&D has, or should have, a large element of public good, as it is both unlikely, and may be undesirable, that innovators capture all the learning benefits. What is more, there are additional indirect benefits to the EU as a whole and its member countries in encouraging other countries to adopt better low-C solutions to reduce global warming, which impacts the EU. These benefits are again not captured by the innovator. Additionally, future market revenues from the exploitation of new clean technologies will be moderate due to the fact that products or services resulting from the use of these technologies (electric energy in the case of low-C generation) will be essentially the same as those resulting from the use of their carbon intensive counterparts (fossil fuel based generation for generation technologies). Therefore, setting aside the carbon price, there will be pure price competition between new low-C technologies and already established high-C ones. Finally, due to the low level of maturity of most clean technologies, market revenues from their exploitation are subject to high uncertainty. All this taken together results in existing demand pull measures within the EU, namely carbon pricing and the Renewables Directive, being insufficient to deliver an adequate and timely level of private RD&D. These arguments are further developed in Newbery et al. (2011). Further public support to be implemented should pull the demand for close-to-the-market technologies (market pull instruments) and finance RD&D to decrease the cost and improve the performance of highly immature ones (technology push instruments).

Regulation induced innovation incentives, like the implementation of standards, or long term commitments to a technology or policy objective, may be cheaper from a public perspective than financial support. However, if standards are set to support immature technologies, they may enforce the adoption of a technology option that ends up not being the most valuable one (though at the time of setting the standard it seemed to be). The mandatory enforcement of long term climate policy objectives alone does not support those clean technologies that currently are not able to compete with more mature ones (those technologies in the pre-deployment stage, which are the focus of our research). Enforcing long term objectives alone would tilt the balance in favor of more mature technologies. This could be very damaging in the long term, where we will also need clean technologies that are now immature but have a high potential. Regulation incentives have a low public cost but, if not applied in combination with other instruments targeted at immature clean options, will not result in the development of a balanced mix of technologies able to achieve long term climate policy objectives at an acceptable social cost. In other words, regulatory support targeting the use of specific clean energy technologies should be reserved for accelerating the diffusion of mature ones ready to be used at large scale, see Popp et al. (2009). Therefore, regulatory support, like other demand pull measures discussed above, cannot replace public funding support of the development of immature technologies. This article provides guidelines on how to frame this funding support.

In any case, public funding support for innovation should complement rather than replace private investments. Public authorities have proved not to be best suited to identify winning technologies, while publicly conducted innovation has generally turned out to be highly cost inefficient.[1] On the other hand, RD&D activities where the private sector has been actively involved have shown, on average, a remarkably higher rate of success.[2]

There is ample evidence of success and failure in the use of public funds to support innovation, mainly in the United States. The authors in Alic et al. (2007) identify those features of climate and technology innovation policies that have led to success and failure within the US. Those in National Research Council (2001) provide an overview of research funded by the US Department of Energy and determine driving factors of innovation success. Cohen and Noll (1991) provide evidence of the inefficient use of public general innovation funds in the US. Experience documented within Europe is scarce. Most published works, like the European Investment Bank's EIB (2010), or the Energy technologies Institute's ETI (2010), provide instances of the application of specific funding instruments but do not discuss results obtained.

Publications collecting experience with the use of different support instruments are complemented by other works conceptually analyzing the use of specific instruments. Some of these works do not address any specific innovation field. Thus, Carpenter and Petersen (2002) and Lerner (2002) argue that public equity investments may be very useful to support any type of innovation conducted in small entities, while Newell (2007) provides evidence of the ability of tax credits to trigger additional innovation of any kind by private investors (both clean and that related to other technologies). Useful insights relevant for any type of innovation can also be found in works relating the use of loans and equity investments in capital markets to the size of the innovating entity (e.g., Williamson, 1991; Vicente-Lorente, 2001; Wang and Thornhill, 2010).

On the other hand, there are also published works specifically targeting support to clean innovation. Thus, Newell (2007) also points out that technology prizes may be a suitable instrument in certain types of clean innovation activities. Newell and Wilson (2005) discuss in depth the use of prizes to support early research in the climate change mitigation area.

Complementing previous research, our work provides a first comprehensive analysis of the use of several main types of policy instruments to fund clean energy innovation. In Section 2, we develop criteria for the assessment of the types of innovation to be addressed with each funding instrument; provide specific recommendations on the use of this instrument in clean innovation processes; and compare the different instruments. In any case, given that main features of any clean pre-deployment innovation project are subject to high uncertainty, we argue throughout the paper that authorities must be willing to reconsider the use of any specific instrument as events unfold allowing them to better understand conditions applying to projects. Afterward, Section 3 is devoted to illustrating the application of

[1] The development of the breeder reactor technology, discussed in Cohen and Noll (1991), is a paradigmatic example of the limitations of publicly managed and conducted innovation. This program was the major focus of US federal RD&D activity from the early 1960s until the cancellation of its demonstration in 1983. Authorities persistently overestimated demand and underestimated the required cost of the development of the breeder reactor technology. When costs exploded, the industry left the project and the federal government took complete control committing further amounts of public funds presumably driven by political considerations rather than socio–economic ones.

[2] However, there are certain types of innovation which are well suited to be publicly managed and/or conducted, as authors in Alic et al. (2003) point out. This is the case of early (basic) research conducted at universities and laboratories, where competition among scholars encourages efficiency in innovation.