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Why and how to subsidise energy R+D: Lessons from the collapse and recovery of electricity innovation in the UK

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HIGHLIGHTS

- We discuss the impact of electricity market reforms on innovation in the UK.
- We show that both R+D expenditure and innovation output have recovered sharply.
- We discuss some of the new institutional arrangements which have support this.
- We conclude that new ways of supporting R+D are needed.

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ABSTRACT

The UK electricity sector liberalisation was a pioneer in the worldwide reform trend and its reform model and outcomes have been the subject of many studies. However, lesser known are the effects of privatisation, market based reforms, and incentive regulation of networks on research and development as well as patenting activities in the sector. This paper updates our previous studies of this subject and discusses the recent developments in the innovative activities in the UK electricity sector. We find that, in recent years, the initial absence of support policies and the subsequent decline in innovation efforts in the aftermath of the reform has resulted in efforts towards forming an energy technology and innovation policy. Although we already observe some positive outcomes from these efforts, we discuss whether the balance of the innovation efforts are calibrated appropriately and whether the institutional framework can be further improved to promote long term progress.

1. Introduction

In this paper we revisit and update some of the research and findings from our earlier papers that documented the theoretical and empirical effects of electricity market liberalisation in the UK (Jamasb and Pollitt, 2008, 2011). Those papers highlighted very significant falls in both public and private R+D in the electricity sector following the privatisation and restructuring of the electricity utilities in the UK around 1990. We showed that both public and private R+D expenditure fell and how this eventually worked through to a large fall (by the year 2000) in patenting by the successor companies created out of the restructuring process. We also noted how strategic subsidies to renewables seem to have supported an increase in patenting by non-utilities and how there seemed to be much less effect on total electricity patents across the economy as a result of what was happening in the electricity supply industry. Our empirical observations were taken up by regulators (in energy and water)[1] in the UK and Norway and used to support the case for the subsequent significant increase of support schemes for utility RD+D projects.

New studies of innovation, drawing on developments in the ICT sector, suggest that different types of innovation can be distinguished and that these require the support of different types of institutional set ups. Meanwhile there has been a significant

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[1] See Cave Review (2011) for water.

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recovery in electricity R+D expenditure from a global low point (around 2004) and this seems to be generating more innovative output in terms of patents. The present paper revisits and builds on our earlier theoretical and empirical observations in the light of the recent developments in the theory of innovation and in the evolution of electricity R+D in the UK. The main aim of this paper is, however, to update the policy lessons to be learned and shed further light on exactly why and how governments can support innovation in the electricity sector.

What follows is organised in four main sections: Section 2 discusses the theory of energy R+D expenditure, innovation and productivity; Section 3 reviews the recent empirical evidence on energy R+D expenditure and innovation output and energy market reform; and Section 4 discusses what the society can do about supporting energy R+D. Section 5 presents the conclusions and some future directions for energy innovation.

2. A brief review of links between energy R+D expenditure and innovation

While the economic and environmental benefits of developing new energy technologies and increasing the efficiency of the existing ones are substantial, the level of R+D investments appears to be low. In economic terms, this represents a case of market failure where the private discount rate for R+D efforts is higher than the social discount rate mainly due to the uncertainty of the outcomes and the ability of private investors to appropriate the benefits. Indeed, energy is already one of the least R+D intensive industries. Part of this investment inadequacy may be due to the relatively slow rate of growth for conventional energy technologies in the mature markets. Moreover, inadequate institutional frameworks and policies and regulatory uncertainty can further add to this disparity in the discount rate between private and public R+D spending (see Gallagher et al., 2012 and PCAST, 2010 for good overview discussions on the energy innovation system, with suggestions about how and why to increase R+D expenditure in the context of the US).

Dooley (1998) first highlighted the empirical observation that energy market reform in advanced countries had produced an unintended consequence in the form of a decline in energy R+D expenditure. In Jamasb et al. (2008a) we discussed that the theoretical conditions for an increase in private energy innovation activities from privatisation and liberalisation of the electricity sector were not observed in practice. Indeed, we have seen that progress was only visible where an active public sector engagement was present. While the need for continuous public sector involvement is now widely accepted, the discussion is increasingly focused on the form and instruments of public support. In practice, this debate has manifested itself in discussions of the relative merits of supporting R+D activities versus offering subsidies for energy generation from renewable technologies. In other words, a key aspect of the debate is whether public involvement should take the form of stimulating learning-by-research versus learning-by-doing – i.e. technology push versus market pull instruments respectively (see Jamasb, 2007).

Total global fossil fuel subsidies in 2013 were $548 bn (IEA 2014, p. 313) and total renewable energy subsidies in 2013 were $121 bn (IEA 2014, p.326). By contrast total global Industrial Energy R+D in 2012 was only $20.6 bn (Battelle, 2013), with total OECD Government Energy R+D in 2011, being a further $18.6 bn (IEA Statistics). Thus given the importance of R+D knowledge stock in driving cost reductions (and service quality improvement), there might be a compelling case for continuing and, even, increasing government support for energy R+D rather than offering subsidies to consumption and production of conventional or renewable energy. There is a well-documented link between energy R+D and energy innovation, as measured by patents (see Namet and Kammen, 2007, who show this for the US).

Recent literature has highlighted the high interdependence between public and private R+D. Even in the EU where public research and development has fallen sharply since 1990, public R+D in 2007 was still 44% of total R+D for Strategic Energy Technologies (i.e. non-conventional technologies), with most corporate R+D being concentrated in wind, PV, biofuels, CCS and smart grids where strategic deployment was heavily subsidised (see Wiesenthal et al., 2012). Interestingly, Popp et al. (2011) show that innovation output (as measured by the stock of patents) is only weakly related to the installed MW of renewable energy, indicating that it is the R+D expenditure push and not the installed MW base pull that is driving innovation.

However there are different types of innovation (Bauer, 2012). Some innovation is modular, while some is coordinated. Some is incremental in nature and some is radical. Each type of innovation requires different types of market and government support. Public R+D support may be particularly useful in some areas (e.g. for radical coordinated research), but not relevant in others (e.g., for incremental modular research).

These ideas link with suggestions for assisting new technologies with crossing the ‘valley of death’ as they move from research projects to technologies being deployed at scale. Both PCAST, (2010) and Weyant (2011) note the potential role of increased funding for post-graduate research as a low risk way to stimulate energy innovation. However US commentators including Alic et al. (2010), PCAST, (2010) and Weyant (2011) suggest the importance of looking to recreating the public-private dynamic observed in semi-conductors and IT in the 1950s and 1960s between the US Department of Defence and its private contractors, which provided long term support at scale for costly innovation. The idea being that energy innovations are, initially at least, public goods best procured from the private sector directly (rather than indirectly) if innovation is to be sufficiently rapid. In this spirit, PCAST (2010) recommend the need for a Quadrennial Energy Review (inspired by the Quadrennial Defence Review) to co-ordinate federal energy policy. Arguably this sort of co-ordinating role is already being undertaken in some EU countries by other agencies, such as the Climate Change Committee in the UK.

A further key idea (Acemoglu et al., 2012) is that there is a path dependency in technological innovation. This means that subsidising ‘clean’ inputs vs. ‘dirty’ inputs may shift technical change on to a different pathway. This may involve shifting research scientists from working on dirty technologies to clean ones. This may be cheaper in the long run than direct support for existing clean technologies.

Thus while electricity sector reform has reduced R+D by conventional utilities and by governments, climate and renewable policies have strongly stimulated R+D expenditure and innovation since 2000. Dechezlepretre et al. (2011) show that countries with stronger climate policy exhibit more patenting for thirteen climate-mitigation technologies. In particular the share of their technologies in all innovations doubles from 1990 to 2005, back to the rate of 1980. Dechezlepretre and Glachant (2014) note that both global and national policies influence domestic innovation. They find that a 10% increase in wind power capacity globally is associated with an increase in domestic wind innovation of around 6%.

3. Empirical evidence on R+D and electricity market reforms in the UK

3.1. Electricity and gas market reform in the UK

The UK electricity industry was substantially reorganised beginning in 1990. The Central Electricity Generating Board (CEGB),