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ANALYSIS

The impact of R&D on innovation for wind energy in Denmark, Germany and the United Kingdom

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Abstract

This paper examines the impact of public research and development (R&D) support on cost reducing innovation for wind turbine farms in Denmark, Germany and the United Kingdom (UK). First we survey the literature in this field. The literature indicates that in Denmark R&D policy has been more successful than in Germany or the UK in promoting innovation of wind turbines. Furthermore, such studies point out that (subsidy-induced) capacity expansions were more effective in the UK and Denmark in promoting cost-reducing innovation than in Germany. The second part of the paper describes the quantitative analysis of the impact of R&D and capacity expansion on innovation. This is calculated using the two-factor learning curve (2FLC) model, in which investment cost reductions are explained by cumulative capacity and the R&D based knowledge stock. Time-series data were collected for the three countries and organized as a panel data set. The parameters of the 2FLC model were estimated, focusing on the homogeneity and heterogeneity of the parameters across countries. We arrived at robust estimations of a learning-by-doing rate of 5.4% and a learning-by-searching rate of 12.6%. The analysis underlines the homogeneity of the learning parameters, enhancing the validity of the 2FLC formulation.

Keywords: Costs; Innovation; Learning; R&D; Wind energy

1. Introduction

The development of environmentally compatible energy technologies has been accelerated in response to the growing concern of the impacts from climate change. However, (liberalized) market circumstances are often unfavorable for those new technologies because they tend to be more expensive than existing but not necessarily environmentally benign technologies. Innovation that leads to cost reduction is therefore crucial for these environmentally benign technologies in order to gain larger market shares, and policy interventions to initiate such innovations are called for. Such policy interventions can be justified on the

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basis of "technological learning". "Technological learning" refers to the phenomenon that the cost of a technology decreases as the cumulative installation of the technology increases (Argote and Epple, 1990; Arrow, 1962; Dosi, 1988; Dutton and Thomas, 1984). Technology policies would stimulate innovation and higher up-front costs could be recovered in the long run after successful technological learning. Without proper policy measures for new technologies, current technologies would however maintain their competitive advantage and remain locked-in a situation relying on technologies that might not be environmentally friendly. In the past, technology-policies such as procurement subsidies and public R&D support have played a key role in promoting cost-reducing innovation of environmentally benign technologies.

In the conventional learning literature, focus is given on the effect of capacity expansion (possibly stimulated by procurement policy) of the cost-reducing innovation. The purpose of this paper is to extend the conventional analysis of the learning effects by including the effect of R&D, based on experience with wind energy in three European countries: Denmark, Germany, and UK.

We focus on wind energy, as it is currently one of the fastest growing energy sources and a carbon-free alternative for traditional fossil fuel based technologies. The selection of the three countries was based on the following arguments: Denmark is the largest global exporter of wind turbines and has the highest per capita levels of wind energy capacity installed. Germany has the highest capacity installed worldwide (BWE, 2000). The UK, in contrast to Denmark and Germany, promoted competition among different renewable energy forms through the introduction of a competitive bidding scheme for subsidies.

Although an abundance of theoretical literature exists on the effects of policy instruments on innovation, surprisingly little empirical research has been conducted (see Jaffe et al., 2001). Our analysis is empirical and based on a review of wind energy policy in the three countries and on technological learning concepts. This paper differs from the existing literature on the relation between policy instruments and innovation for wind energy (e.g., Hemmelskamp, 1999; Loiter and Norberg-Bohm, 1999; Mitchell, 1995, 2000) since the focus is on the quantification of the impacts of policy instruments on innovation (i.e., public R&D).

The quantification was done based on a modified version of the two-factor learning curve (2FLC) model introduced by Kouvaritakis et al. (2000). The 2FLC is an extended version of the conventional learning curve (based only on cumulative capacity) in that it includes both cumulative capacity and knowledge stock (resulting from past R&D expenditures). This is a rather novel concept and its empirical validation has not yet been demonstrated successfully. So far most top-down models only deal with R&D and most bottom-up energy models focus on cumulative capacity. Thus, the most important contribution of this paper is to attempt to bridge the gap between the two approaches. Secondly, wind power as a source of electricity can be considered to contribute to sustainable development given the relatively low externality impacts associated with wind power installments (see e.g., Sundqvist and Söderholm, 2002). In this paper we look into the policies to promote wind energy technology as a way to move towards sustainable development.

Section 2 describes the different policies in the three countries to promote the diffusion of wind energy and summarizes the literature on the impacts of R&D and (policy-induced) capacity expansions on innovation in these countries. Section 3 introduces the two-factor learning curve model that is used to assess the impacts of policy instruments on cost reducing innovation. Section 4 summarizes the data for our panel analysis. Section 5 gives the results of the econometric analysis. Section 6 concludes and discusses the results obtained.

2. Policy instruments for promoting innovation in wind energy

Progress in wind turbine technology can be attributed to R&D programs and accumulated experience in producing wind turbines. Capacity expansion leading to enhanced experience in producing wind turbines can partially be gained by financial incentives to increase demand such as subsidies. This section will have a closer look at R&D programs and demand-based incentives in three European countries for promoting wind energy.