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Effects of policies on patenting in wind-power technologies

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ABSTRACT

This paper explores the effects of policies and other factors driving innovation in wind power technologies in twelve OECD countries over more than two decades. Patent counts are used as an indicator for innovation. The factors considered are generally derived from the systems of innovation literature. Count data econometric model were used for the estimations. The suggest that patenting in wind power technology is positively related to public R & D in wind power (reflecting supply-side policy), the stock of wind capacity (reflecting learning effects), the number of patents per capita (reflecting a country's innovative capacity), and the share of Green party voters (reflecting the legitimacy of the technology). In particular, the presence of production or capacity targets for wind power or renewable energy sources and a stable policy environment (reflecting policy process) appear to be favourable for patenting wind power technologies. These results are robust to various model specifications, distributional assumptions, and alternative classifications of wind power technologies in the patent search.

1. Introduction

Expanding renewable energy sources (RES) is considered to be a key strategy for tackling climate change, preserving resources, and securing energy supply. For example, the European Union (EU) has set a binding target of 20% for the share RES in final energy consumption in 2020. For 2030, this share is 27% and current debates focus on the support of RES in the EU beyond 2020 (European Commission, 2015). As a key component of decarbonising their power sectors, several countries, including Denmark, France and Germany, have passed energy transition laws", which mandate a sharp increase in RES. To achieve these targets innovation efforts may enhance performance and help lower the costs of electricity generation from RES.

Policy support for innovation in RES technologies is typically justified by positive technology and knowledge spillovers and by RES's avoidance of external costs associated with the generation of electricity from conventional sources (e.g. Rennings, 2000). Because of these market failures, private innovation would be lower than socially optimal without policy intervention. Since environmental policies also act as demand-side innovation policies, more recent work calls for innovation and environmental policies to be investigated jointly (Horbach et al., 2012; Costantini and Crespi, 2013; del Río Gonzáles and Peñasco, 2014). Complementary to approaches which justify policy by market failures, the systems of innovation (SI) approach emphasizes the need for systemic innovation policies to improve the functioning of the innovation system and prevent "system failure" (Smits and Kuhlmann, 2004; Lundvall and Borras, 2005; Klein Woolthuis et al., 2013).

Only few studies have yet analyzed the impact of policies on innovation in RES technologies based on large samples (Lee and Lee, 2013, p. 415). Notably, Johnstone et al. (2010) econometrically explore the effects of public expenditures on research and development (R & D) and of support mechanisms for RES on patenting in OECD countries between 1978 and 2003. Yet, their analysis does not allow for other policy factors which have been identified as impacting patenting. The SI literature stresses the importance of specific innovation functions for innovation, in particular. Policy can influence the functionality of an innovation system by removing blocking and adding inducing mechanisms (Bergek et al., 2008a). In addition, the policy analysis literature points to the role of target setting and policy stability for innovation activities (e.g. Jänicke and Lindemann, 2010; Bergek et al., 2008a).

In this paper, we econometrically explore the factors driving patenting activity in wind energy technologies, relying on data for twelve OECD countries over the time span of 1991–2011. These factors include supply-side policies such as technology-specific R & D, and demand-side policies such as support mechanisms for electricity generated by RES. Relying on the comprehensive functions of innovation approach as a conceptual framework, we extend previous studies

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of patenting activities in RES power technologies - notably Johnstone et al. (2010) - by also including factors derived specifically from the SI and the policy analysis literatures, thereby complementing existing case-study based approaches in the SI and policy analysis literatures. We focus on wind energy because wind power is typically considered to exhibit the largest future potential among RES power technologies (IEA, 2014). Our sample also captures the more recent and also more dynamic developments in wind power patenting since the late 1990s. As a robustness check of our findings, we also allow for a more comprehensive classification of patents in wind-power technologies than previous studies.

Section 2 provides an overview of the literature and the conceptual framework used. Section 3 presents the methodology, including a description of the data, the variables, and the econometric approach. Results are shown and discussed in Section 4. Section 5 summarizes the main findings and offers policy implications.

2. Literature review

2.1. Conceptual framework

Since the 1990s, researchers have employed the SI heuristic to study innovation activities. In particular, the technological innovation systems literature has identified several functions that innovation systems need to fulfil to spur innovation (e.g. Jacobsson and Johnson, 2000; Smits and Kuhlmann, 2004; Hekkert et al., 2007; Bergek et al., 2008a; Heckert and Negro, 2009). These functions may be categorized as: creation and development of knowledge (F1); creation of positive external economies via exchange of information and knowledge between producers and along the value chain, including user-producer interaction (F2); guidance of the search for new technological solutions and markets (F3); creation of the legitimacy of a new technology and counteracting resistance to change (F4); facilitation of market formation (F5); supply of resources, especially for new technologies with a high risk of failure (F6); and diversity in experimentation and a variety of solutions (F7). These functions overlap and involve interactions and feedback loops. Recognizing that the actors who perform the functions respond to policies, the SI approach encompasses the traditional demand-pull and technology-push factors in a more systemic framework, but does not regard innovation as a linear process.

The policy instruments discussed in the innovation policy literature may affect the functionality of an innovation system by removing mechanisms which block the actors performing functions, or by adding mechanisms to support those actors. Supply-side regulation attempts to affect the innovation process per se and contributes to the creation and development of knowledge (F1). Traditional supply-side policies include technology-specific measures such as subsidies for R & D for particular technologies, cross-cutting policies such as the protection of intellectual property rights, and the standardisation of products and processes via norms (e.g. Blind, 2008). Subsidies for R & D, in particular, provide resources for the actors creating knowledge and developing new technologies (F1, F6) and facilitate the exchange of information (F2). Technology-specific R & D support also provides guidance of search (F3).

Demand for wind turbines is blocked, for example, because the costs of generating electricity from fossil fuels do not reflect the associated environmental damages so that electricity prices are lower than socially optimal. In this case, domestic demand-side policies enable market formation (F5) by providing support for production and, thus, for investment in technologies which are less harmful to the environment. There are various channels how this will foster innovation (e.g. Lundvall, 1988; von Hippel, 1996; Edler and Georghiou, 2007): The interaction between users and producers of an innovation transfers knowledge about preferences, customers and real-world operation conditions from the market to the technology providers. Thus, the exchange of knowledge (F2) is fostered. Furthermore, learning-by-doing in the production process of the innovation and utilizing economies of scale can improve product quality and drive down costs. In addition, demand-side policies may lead indirectly to the supply of resources (F6), as revenues from sales help to recover the costs of innovations.

Demand-side instruments for RES include measures supporting deployment such as feed-in tariffs (FITs), which make fixed payments to electricity generators for each kWh of electricity supplied from RES. Other support mechanisms include investment subsidies or tax exemptions, production tax credits (PTCs), quota obligations for the share of RES electricity generated or distributed, and tradable green certificate (TGC) schemes. Higher support levels generate higher profits which can then be used for additional innovation. By creating sufficient demand, these mechanisms help establish markets for high-cost RES technologies and overcome the technological fossil fuel lock-in in the energy sector (F5) (Unruh, 2002). Most theoretical and empirical studies consider market-based support mechanisms such as TGCs, FITs or PTCs to have stronger effects on innovation than command-and-control instruments like non-tradable obligations, since the latter provide lower financial incentives to advance technologies beyond the required standard (e.g. Jaffe et al., 1999). The thrust of the literature further suggests that FITs are more conducive to diffusion and innovation than TGC because they provide more predictable price incentives for investors (e.g. Schmidt et al., 2012; Bergek and Berggren, 2014). Such investment security is particularly relevant for investors in technologies like wind power, where capital costs account for a high share of total generation costs (e.g. Kleßmann et al., 2013).[1] FITs might therefore lead to a higher level of innovation than other mechanisms because they have a stronger effect on demand.

Similar to domestic regulation, foreign regulation may also enable market formation (F5), which indirectly facilitates the supply of resources (F6), user-producer interactions and learning effects (F2) (e.g. Wagner, 2007; Wei Yingqi et al., 2008). Likewise, a greater number of innovations may induce higher exports in the future, reinforcing the positive relation between exports and innovation (e.g. Fagerberg, 1988; Dosi and Soete, 1988; Sanyal, 2004; Madsen, 2008).

The SI literature stresses, in particular, the importance of learning, of a country's innovative capacity, and of technology legitimacy for innovation. Accordingly, learning-by-doing, learning-by-using, and learning-by-interacting (user-producer interaction) (F2) lead to patenting of new products and processes (e.g. Smits and Kuhlmann, 2004; Lundvall, 1988; von Hippel, 1996). Learning effects are also linked with market formation. In particular, incorporating user knowledge into the design process may be conducive to innovation, allowing for knowledge to spill over to domestic actors through various channels, including “reverse engineering” in cases where technologies are imported (e.g. Boon et al., 2011; Nahuis et al., 2012; Peine and Hermann, 2012). Technology diffusion further signals commercial opportunities for (potential) domestic technology producers and may also stimulate domestic innovation activities eventually leading to patenting. A country's higher scientific and technological know-how also nurtures innovation activities by companies (F1) (e.g. Nelson, 1993). Finally, a higher perceived legitimacy of technology translates into the greater market success of a new technological paradigm (F4). Similarly, the greater potential and performance ascribed to a technology facilitates legitimacy and increases further innovation activities (Bergek et al., 2008b). A second aspect of legitimacy relates to the power to change existing rules and institutions, e.g. via the ability to influence public policy (Hekkert and Negro, 2009) and to challenge existing technological regimes (Walz and Köhler, 2014).

The policy analysis literature stresses the importance of target

[1] Capital costs account for about 80% of the levelized costs of wind power generation (IRENA, 2012).