EFFECTS OF POLICIES ON PATENTING IN WIND POWER TECHNOLOGIES

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Overview

Expanding renewable energy sources (RES) is considered to be a key strategy for tackling climate change, preserving resources, and securing energy supply. thereby relying on technologies which enjoy high social acceptance rates. As a key component of decarbonising their power sectors, several countries, including Denmark, France and Germany, have recently passed "energy transition laws", which foresee a sharp in-crease in RES over the next two to three decades. To achieve these targets at low cost, innovation efforts are needed which to help increaseing performance and lower theing costs of electricity generation from RES.

To date, there is only scant empirical literature analysing the impact of policies on innovation in RES power technologies based on large samples. In particular, Johnstone et al. (2010) focus on the effects of R&D and of different support mechanisms. Thus, the set of policies considered does not reflect other policy factors which may impact patenting. Notably, the systems of innovation literature stresses the importance of innovation functions which have to be fulfilled, such as knowledge creation and exchange, entrepreneurial activities, guidance of search, early market formation, and legitimacy of technology (e.g. Bergek et al. 2008; Heckert and Negro 2009). In addition, the policy analysis literature points to the role of target setting and policy stability for innovation activities (e.g. Bergek et al, 2008). Yet, the impact of these broader effects on innovation activities in RES power technologies has only been explored using case studies, which allow findings to be generalized in an analytical sense but not in a statistical sense.

This paper explores factors driving innovation in wind power technologies. In addition to classical supply side policies, the set of explanatory variables also reflects insights from the systems of innovation and policy analysis literature.

Methods

This study employs panel econometrics to estimate the impact of policy on patenting activity, relying on a time series (1991 to 2011) of cross-sectional data for twelve OECD countries: Austria, Denmark, France, Germany, Italy, Japan, the Netherlands, Spain, Sweden, Switzerland, the United Kingdom and the United States. Country choice was mainly motivated by their importance for patenting in wind power technologies during the period considered, as well as data availability. The countries included in our sample, account for 75 to 90 percent of total annual global wind power patents in any given year. Of the countries, which have very recently become more relevant for wind power patenting, only China and Korea are missing from our sample.

We use the number of patents for wind power technology (*patents*) as the dependent variable (European Patent Office, sub-class F03D). The explanatory variables include include, as a classical supply side policy, public R&D expenditures for wind power including onshore and offshore technologies and wind energy systems and other technologies (*r&d*). To capture demand-side policy effects, we include a dummy variable, FIT, which takes on the value of one if a FIT was in place in a specific year. Similarly, we include the dummy variable NOFIT, which is equal to one if other-than-FIT support mechanisms were implemented. We further include the export volume of wind power technologies (*export)* which is meant to roughly capture the impact of export demand (e.g. via foreign support mechanisms) on domestic patent activity. Learning effects are captured by the cumulative capacity of wind power installed in a particular country (*windcap*). We further include the number of total patents (net of patents for RES) per capita (*patents_all_pc)* to proxy a country's innovative capacity. As a proxy for legitimacy of technology we include the share of votes for green parties at national level during the most recent election (*greenvote)*. To further capture factors of innovation identified in the policy analysis literature, we employ two variables. First, *target* takes the value of one of if a national target is in place for electricity generated from wind power or from renewable energies in general. Second, we capture the impact of the stability of the regulatory framework via a dummy variable *stability,* which equals one if there is a stable regulatory framework in place *and* a supportive regulatory framework exists (e.g. provisions for integration of power from RES into the grid, building codes, standards) and if there are information and education programs in place. Additional control variables include the price of electricity (*powerprice)* to capture financial incentives, and the number of patents in technologies for RES (net of patents for wind power technologies), *patents_reg*, to control for changes in the propensity to patent in RES over time and across countries. The model is specified as:

$$(1) \quad patents_{i,t} = constant + \beta_1 r\&d_{i,t-1} + \beta_2 FIT_{i,t-1} + \beta_3 NOFIT_{i,t-1} + \beta_4 export_{i,t-1} + \beta_5 windcap_{i,t-1} + \beta_6 patents\_all\_pc_{i,t} + \beta_7 greenvote_{i,t-1} + \beta_8 target_{i,t-1} + \beta_9 stability_{i,t-1} + \beta_{10} powerprice_{i,t-1} + \beta_{11} patents\_reg_{i,t} + \alpha_i + \varepsilon_{i,t}$$

where $i = 1,...,12$ indexes the cross-sectional units (countries) and $t = 1991,..., 2011$ indexes time; α_i represents an unobserved country-specific effect (unobserved heterogeneity), and $\varepsilon_{i,t}$ is the usual idiosyncratic error term. In the estimated specification, most explanatory variables enter with a lag of one period recognizing that companies take time to mobilize the resources to respond to policy and market factors. Since *patents_regl* is supposed to control for general trends in the propensity to patent for renewables, it is not lagged. Lagging explanatory variables is also expected reduce potential endogeneity problems related to the policy variables. Equation (1) is estimated as a negative binomial specification to reflect the count nature of the dependent variable (the number of patents). The modell is estimated as a fixed effects (FE) model. Robustness checks are conducted employing random effects models, unconditional FE negative binomial, generalized poisson models and different lag structures of the explanatory and control variables.

Results

Patenting activity was found to be positively correlated with specific public R&D spending and with learning-by-doing (as proxied by the stock of wind power capacity). Unlike predicted though, export demand did not exhibit a statistically significant effect on patenting activity in most models estimated. In contrast to some case study analyses, yet consistent with the previous econometric work (Johnstone et al. 2010), the presence of FIT was not associated with stronger patenting activity for the standard model specification. Further, we found patenting activities in wind power to be positively related to learning to a country's innovation capacity (either measured as patents per capita or as stock of past patents in wind technologies), to legitimacy of technology (as proxied by the share of Green party votes), and to the presence of production or capacity targets for wind power or electricity from RES in general. We further observed that a more stable policy environment is favourable for patenting wind technologies. Interestingly, by allowing the FIT and NOFIT support mechanisms to interact with the stability of the regulatory framework, we discovered a positive and statistically significant correlation of this interaction term for FITs. Thus, the support mechanisms are conducive to patenting (only) when the regulatory environment is stable. Electricity prices were also positively related to patenting in wind power, in particular when lagged by two rather than one year. Thus, it may take firms longer than implied in the extant literature to respond to power prices and to mobilize the resources leading to new patents. Finally, we found that the patenting of wind power technologies was positively associated with general patenting activity in renewable energy technologies in a country. This may reflect general country-specific tendency and trends to patent in renewable technologies. Likewise, there may also be positive spill-over effects from innovation activities across renewable technologies.

Conclusions

Our econometric analysis of international patents in wind power technologies using a panel of twelve OECD countries over the last two decades supported the predictions that innovation is related to standard supply-side and demand-side policies, and also to broader factors shaping innovation which were derived from the systems of innovation and the policy analysis literature. These findings were robust to alternative model specifications and distributional assumptions.

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