**The innovation impact of the policy mix for renewable power generation: a survey analysis of German technology providers**

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Theme: 4. Power, politics, institutions and the reality of achieving change

Subtheme: 4.3. Getting there from here: viable frameworks for planetary problems

*Alternatively:* 7.27. From incremental to radical transformation: reconciling energy systems with 2°C carbon budgets

**Summary**

The decarbonization of energy systems constitutes one of this century's key challenges for human society. In such a transition so-called policy mixes play a crucial role in redirecting and accelerating technological change towards low-carbon solutions. Yet precisely how policy mixes affect technological innovation remains poorly understood. In this paper we present new insights into the link between policy mix and innovation based on a company survey among German manufacturers of renewable power generation technologies which was conducted between April and July 2014. Based on a bivariate Tobit model we confirm the positive innovation effect of demand pull and technology push instruments. In addition, we find that perception of companies regarding the consistency of the instrument mix and the credibility of the overarching policy mix are positively associated with the level of their future innovation expenditures. Based on these findings we derive policy recommendations and point to future research needs.

**Abstract**

The decarbonization of energy systems constitutes one of this century's key challenges for human society in the fight against climate change (van Vuuren et al 2013). In such a transition so-called policy mixes play a crucial role in redirecting and accelerating technological change towards low-carbon solutions (Rogge and Reichardt 2013). Yet precisely how policy mixes affect technological innovation remains poorly understood. Rather, studies so far have focused on the impact of single policy instruments on environmental innovations, and also on their stringency as one of their design features (Kemp and Pontoglio 2011). However, in reality complex policy mixes are at play, implying that studies should focus on the interaction of policy instruments (Flanagan et al. 2011) and on overarching characteristics of such policy mixes, such as their consistency (Rogge and Reichardt 2013).

We address this gap in the literature by studying the case of the German Energiewende. More precisely, we analyze the role of the policy mix for firm-level innovation activities in renewable power generation technologies within the German power sector. Since this sector is supplier-driven (Pavitt 1984) we focus on German technology providers, and extend existing qualitative work in the sector (Rogge et al. 2011, Hoppmann et al. 2013) by conducting a suryey of companies' innovation activities. The questionnaire for this survey was designed in line with the Community Innovation Survey, but was adjusted to the context of renewable power generation technologies and extended by a questions on companies' perceptions of the policy mix. The survey was conducted by telephone from April 9 until June 22, 2014, with interviews lasting around 30 minutes. In this time period we contacted all German renewable power generation manufacturers and suppliers and achieved a response rate of approximately 36% (n=390).

In our econometric approach we employed a bivariate Tobit model to estimate R&D expenditure equations for the years 2014 and 2015, where the error terms captured possible correlations between R&D expenditures in different years. In this case, the use of univariate Tobit probit models can lead to biased and inconsistent parameter estimations (e.g. Greene, 2012). The simulated maximum likelihood estimations were carried out with STATA 13, relying on Barslund (2009).

Findings of our econometric analysis suggest that R&D expenditures in both years are larger for companies with higher current and expected future turnovers (including export) in the respective renewable power generation technology, which is in line with other studies on the key relevance of domestic and foreign demand pull instruments (Peters et al. 2013). Likewise, higher R&D expenditures are positively related to the amount of subsidies received for R&D from German or EU public funding bodies, thereby confirming the importance of technology push instruments for innovation. Further, future R&D spendings are larger if respondents perceive the current instrument mix to be consistent in its support of renewable energy, and if they perceive a high credibility of the overarching policy mix, as measured by the uniform cross-party support for the expansion of renewables within the German Energiewende. This confirms and extends qualitative findings for offshore wind in Germany pointing to the importance of policy mix consistency and credibility for R&D and adoption activities of emerging renewable power generation technologies (Reichardt and Rogge 2014). Finally, the time a company has been on the market for the respective renewable power technology considered is positively related to the magnitude of innovation expenditures, i.e. more experienced firms invest more in innovation.

Based on our findings we derive recommendations for policy makers on how to tailor policy mixes to support innovation in green technologies. These policy implications are not only relevant in the context of the German Energiewende but for any country aiming to

promote environmental innovation activities of manufactures and thereby sustainability transitions, such as the transformation of energy systems towards higher shares of renewables. We also point to limitations of our study based on which we derive future research needs.

## Acknowledgements

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