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Exploring heterogeneous growth of wind energy across Germany

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ABSTRACT

Expansion of renewable energies in Germany is strongly associated with decentralization of energy provision. In the case of wind energy there are especially strong regional-level spatial, technical, economic, and social ramifications of this energy source. In addition to differing natural conditions and the strong push from the federal feed-in tariffs, policies and initiatives at the state, county, and municipal level need to be considered when explaining the pattern of wind energy expansion across time and space and to improve the coordination of multi-level energy policies. This paper uses panel regressions at the level of German counties from 2001 to 2012 to explore the growth of wind power capacity. Based on the estimates obtained, we then analyze counterfactual scenarios in which factors influenced by the regional (county) level are varied individually. Our focus is on party policy preferences and coalitions on the one hand, and the unemployment rate on the other. While strict causality is difficult to establish, our results reveal heterogeneous incentives between states, within states, and between different county types.

1. Introduction

Expansion of renewable energies in Germany is strongly associated with decentralization of energy provision, which is evident in the regional-level spatial, technical, economic, and social ramifications of renewable energies. This is particularly true for wind energy given its spatial dimension, its volatility in providing electricity, and its economic and social impacts in mostly non-urbanized areas.

To explain the pattern of wind energy expansion across time and space, policies and initiatives at the state, county, and municipal level need to be considered, given that states, counties, and municipalities influence the legal and administrative conditions for implementing renewable energy projects. These entities are also free to set their own renewable energy targets and incentivize expansion of renewable energies to attract investment, create employment opportunities, become relatively independent from external energy supplies, or realize other social goals. Moreover, it is not just local or regional policymaking per se, but civil society initiatives and networks that create different conditions for the expansion of renewable energies across Germany. Yet, policy discussions often focus exclusively on the strong federal-level push for renewable energies, notably the Renewable Energy Act (REA) and its reform. At the sub-national level, much of the discussion of this issue revolves around the problems posed by the country's considerably varied natural and geographic conditions.

It is important to know more about the differing incentives for expanding renewable energy at various sub-national spatial levels. At present, renewable energy goals vary widely across levels of government and across states. For example, the federal government aims to achieve a 35% share of renewable energy in electricity consumption by 2020 according to the so-called energy concept, whereas the aggregated goals of the states amount to between 50 and 55%. As a result of this uncoordinated approach, as well as due to the intermittent nature of wind energy, the characteristics of the power and carbon market, and the planning of infrastructure networks, the electricity system can incur substantial additional costs (Gawel and Korte, 2015).

There are few empirical analyses of the evolution of renewable energy and their determinants across German "regions".[1] Most previous research is based on regional case studies and focuses on issues related to participation in wind power planning and acceptance of siting decisions (e.g. the contributions in Gailing and

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[1] We use "region" as an umbrella term for the local, county, and German-state level.

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Leibenath, 2013), but mostly ignores the national dimension of heterogeneous growth patterns in renewable energies. Diekmann et al. (2008, 2010, 2012) provide an extensive set of indicators that are used to identify best practices in policies for renewable energies and to create a ranking among the German states. The only quantitative econometric analysis of wind energy in Germany based on disaggregated county-level data is Hitaj et al. (2014), but even this paper does not explicitly investigate regional differences in growth rates or regional determinants.

Previous studies beyond Germany consider whether differences in wind energy deployment are more strongly related to physical and geographical factors or to socioeconomic and institutional factors. For example, the statistical analysis by Staid and Guikema (2013) for U.S. states suggests that wind resources, the amount of cropland, and the available percentage of land are the most influential parameters, whereas state policies appear to play only a small role in predicting wind power development. By contrast, Toke et al. (2008) compare wind power development in six EU countries (without aiming at statistical generalizations). They find that in addition to regional wind resources, the level at which investment and siting decisions are made and who is involved in such decisions are among the most important deployment factors. Following the widely cited study by Toke et al. (2008), other qualitative or semi-quantitative studies emphasize institutional and political factors in uneven wind power deployment (e.g., Ferguson-Martin and Hill, 2011 for Canadian provinces and Frantál and Kunc, 2010 for Czech regions).

Most of the econometric studies on wind energy that focus on state-level policies and/or the interaction of national and state-level policies are conducted for the United States (for an overview, see Shrimali et al., 2015). Shrimali et al. (2015) find that in many cases the central national policy enables various state-level policies to become more effective. Moreover, a state's responsiveness to renewable energy policies seems to depend on the state's resource potential for that renewable energy.

However, the institutional setting and the policy context of the United States is substantially different than that of Germany. Moreover, many of the wind-related policies and initiatives at the state, county, and municipal level in Germany are difficult to measure and compare consistently, since they rely on complex planning decisions, multi-stakeholder negotiations, and other more informal ways of either facilitating or impeding the placement of wind turbines. Given these constraints, the quantitative, top-down approach we pursue in this paper does not claim to provide a causal evaluation of regional policies. Our primary aim is to advance a type of analysis not as yet employed in this context and to reveal policy influences at the regional level by looking at a restricted number of variables. Building on prior work, we first apply panel regressions at the level of German counties (Kreise)[2] to account ex post for the growth of wind power capacity in general. Then we undertake a counterfactual analysis to explore heterogeneous growth of wind power capacity for differing regions, mainly operationalized as states and/or so-called county types. While, potentially, the number of institutional and policy influences at the regional level is large, this paper is related to Ohler (2015), who analyzes whether the rise of renewable energy is mainly due to concerns over environmental quality or to those involving rising unemployment.[3] Therefore (and based on the background provided in Section 2), we consider regional policy preferences on one hand, and unemployment rates on the other. Although strict causality is difficult to establish, our results reveal the role of regional (energy) policies and initiatives beyond or in combination with the differing natural and geographical potential of wind energy.

Section 2 provides a conceptual and policy background for the empirical part of the paper. Data and employed variables are described in Section 3. Section 4 explains the empirical strategy and how the counterfactual analysis is specified. Results are presented in Section 5. Section 6 concludes.

2. Conceptual and policy background

Economic theories of location and agglomeration provide some basic insight into the placement and concentration of renewable energy installations across German regions. The literature contains two main approaches for explaining agglomeration: an exogenous approach and an endogenous approach. The first focuses on the natural advantages of certain regions vis-à-vis other regions; the second emphasizes agglomeration economies created by the physical interaction between firms, between firms and households, or between human beings more generally. Krugman (1993) uses the terms “first nature” and “second nature” to distinguish between these approaches.

Clearly, the “first nature” is of crucial importance for electricity production from renewable energy in general and from wind energy in particular. Due to their transportability, fossil or nuclear-based electricity generation does not necessarily need take place where the resources are extracted. However, transportation of inputs across space is impossible in the case of wind energy. Generating power from windmills is critically dependent on weather conditions, particularly average wind speeds. More specifically, wind yields depend on elevation, surface roughness, topographic form (e.g., change between valleys and hills), and other localized factors (DWD, 2013). Wind power is also relatively space-intensive; on average, 7 ha/GWhel are required (BMVBS, 2011). In addition, many areas are unsuitable for the erection of wind turbines, including built-up areas, water bodies, and (arguably) forest land. This results in saturation effects in areas with favorable wind conditions but limited land availability.

The “second nature” has to do with endogenous advantages or disadvantages of agglomeration resulting from interaction of firms or of firms with other stakeholders (e.g., Bröcker and Fritsch, 2012). Some of these factors are likely to influence firms in the renewable energy sector as well. Economies of scale due to fixed costs (e.g., regionally bound overhead) and transaction costs (e.g., ease of interaction with local community) might explain the geographic concentration of wind manufacturing and/or wind plant service providers and operators. Similarly, knowledge and innovation are important assets in a relatively new industry like renewable energy. The knowledge needed for production and/or installation of wind turbines has a number of characteristics that lead to agglomeration advantages, including fixed costs in knowledge production, public and network-good characteristics, uncertainty, and the importance of face-to-face contacts.

Differences in the generation of wind power across states are also likely to be driven by increasing returns on the demand side. These effects might relate to grid operators learning how to best integrate fluctuating wind energy into the grid. Some evidence suggests that citizen involvement in wind energy projects varies by region, creating differences in the level of acceptance of wind power production (Jakubowski and Koch, 2012). For example, some regions in northern Germany are well known for their pioneer inventors in wind energy and citizen wind parks (*Bürgerwindparks*) where citizens hold stakes in wind energy projects, thus paving the way for further expansion (Simmie et al., 2014). However, the different level of renewable energy shares across regions is also likely to result from

[2] Counties (*Kreise* and *kreisfreie Städte*) are municipal associations with municipal self-government rights.

[3] Ohler suggests that promoting renewable energy projects as a means of creating jobs is one of the main drivers of these projects.

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