Spatial Analysis of the Effects of the Dismantling of End-Of-Life Wind Turbines in Germany

Imke Rhoden, Institute of Energy and Climate Research - Systems Analysis and Technology Evaluation, Forschungszentrum Jülich, D-52425 Jülich, Germany, +49 2461/616728, i.rhoden@fz-juelich.de
Stefan Vögele, Institute of Energy and Climate Research - Systems Analysis and Technology Evaluation, Forschungszentrum Jülich, D-52425 Jülich, Germany, +49 2461/613393, s.voegele@fz-juelich.de
Andrew Ross, Institute of Energy and Climate Research - Systems Analysis and Technology Evaluation, Forschungszentrum Jülich, D-52425 Jülich, Germany, +49 2461/611798, a.ross@fz-juelich.de

Overview

Macroeconomic impacts being linked with construction and use of photovoltaic cells and wind power plants have been emphasized in many studies (e.g., Allan et al., 2020; Graziano et al., 2017; Mattes, 2014). Regarding impacts being related to the end-of-life (EOL) of these technologies, currently most studies focus on waste forecasts or impact analysis of investments and not on employment or changes in value added. (e.g., Costa & Veiga, 2021; Shoeib et al., 2021). Our study aims to contribute to close this research gap.

The increased deployment of renewable energy and is linked with rising demand for production inputs such as concrete, steel, and fiberglass that have to be disposed of or recycled. Wind turbines, in particular, consist of several construction elements, which are renewed at certain intervals due to their limited technical service life or due to further technical development (repowering). If these construction elements cannot be reused at other locations, they must be disposed of as waste based on the regulations of the Closed Substance Cycle Waste Management Act. Still, the aforementioned components of wind turbines can be almost completely recycled. If the volume of wind turbines requiring disposal increases, experts assume that the disposal market will react to this and additional capacities may be made available. In our model, we focus on wind turbines, as many wind power plants will reach their EOL soon, particularly in Germany. After a lifespan of 20-25 years, parts of the wind turbines are currently disposed of either as landfill or are thermically reused in the cement industry, as recycling them in a sustainable manner is an option that is still left to be exploited. In Figure 1 the coverage and dispersion of wind turbines in Germany can be observed. Corresponding to wind power potential, most plants are located in Northern regions. Especially in these regions, the EOL and need for dismantling can create substantial effects for regional employment, which is why we look on these macroeconomic impacts being linked with dismantling of wind power plants.

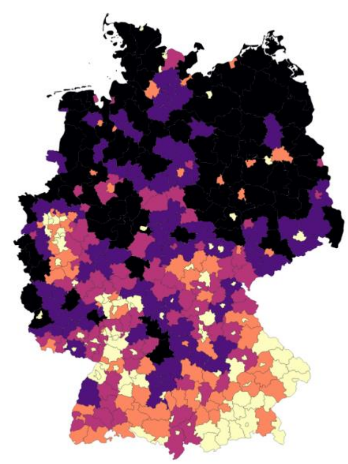

Figure 1: Number Wind Turbines Aggregated on NUTS-3 level. Source: Own compilation based on Bundesnetzagentur 2022.

Methods

Using spatial econometric modeling, we investigate the effects of wind turbine dismantling in Germany on employment on regions on NUTS-3 level. We divide estimated results into impacts of direct and indirect effects, including regional spillover effects. Our sample consists of 401 German regions on NUTS-3 level across 2009-2019. We investigate whether spatial linkages between regions affect other neighboring regions and after testing for spatial dependence, we execute a spatial durbin model (SDM) to account for spatial autocorrelation, which is able to detect spillover effects of the regional shift arising from the dismantling of wind turbines. The SDM incorporates spatial lags of the dependent and the explanatory variables by including a spatial weight matrix based on distance related neighborhood effects (LeSage & Pace, 2009). We build a spatial weights matrix and we assume that contractors for dismantling can originate from all regions in Germany and are not locally based in the region where a turbine needs dismantling use a global spillover specification. For the effects of wind turbine deployment, we use data provided by the German Bundesnetzagentur about the exact geographic locations of turbines, the year of their initial operation, and multiply the aggregated number of turbines in a region with the cost of dismantling (Bundesnetzagentur, 2022). To control for the economic structure in a region, we include gross value added of the industry sector to account for productivity in a region, the share of human capital employed in knowledge intensive industries as indicator for innovation potential, and regional population density (BBSR, 2022; Eurostat, 2022). Additionally, we include a dummy variable indicating the presence of manufacturers of wind turbines in a region, as effects on employment in those regions could be attributed to productivity gains by these companies. We estimate the model as twoway-fixed effects and as a random effects specification, as only the latter can account for the dummy variable of turbine manufacturers.

Results

Our model shows that effects of turbine dismantling on employment can not be attributed to the region where dismantling happens, but to neigboring regions. In region i, the coefficient is negative, whereas it is positive for neigboring regions j. Still, the dismantling effect is marginal, with a 1 percent increase affects employment in region i by -0.00007 percent and in regions j by 0.0000006 percent, although the effect is not significant. However, the results from the SDM indicate that the spatial coefficient ρ is highly significant and positive, meaning that impacts of other regions influence region i via a multiplier of $\rho = 0.21$. Highly significant are gross value added the industry sector (positive) and in the indicator for knowledge intensity (negative for region i, but positive spillovers), where the knowledge indicator is only significant for region i, not in regions j. For turbine dismantling, there seems to be a different pattern than for industry in general, indicating heterogeneity and specificity in skills needed for dismantling, which spillover to neighboring regions. Population density is significant across all regions, as these regions coincide with high employment. LaGrange multiplier tests indicate that spatial dependence is present in the data and that a global spillover specification is appropriate, spatial error correlation is not needed. Hausman-tests indicate further that the fixed effects specification is preferred to the random effects specification. However, the random effect specification exhibits a positive effect of the dummy variable of turbine manufacturers of 0.3 percent, which supports the notion of special labor force and capital needed in the wind turbine construction/dismantling sector.

Conclusions

Our analysis shows that employment impacts resulting from the dismantling of wind turbines are a spatially relevant issue that affect the region of the wind turbine location negatively, but exude positive spillovers to neighboring regions. As it is expected that a peak of the EOL of wind turbines will occur 20 years from now on (Volk et al., 2021), effects on regional employment are not necessarily only local, but global and spilling over to all regions. Building a circular economic structure for the implementation of recycled glass fiber based products in the chemical and cement industries could magnify these effects. With increasing replacement of raw materials, a shift between industry processes and resources is to be expected. With our model, we are able to emphasize the shift of implementing recycling on the economy, disentangling regional effects beyond the direct effects of the shift of material flows.

References

Allan, G., Comerford, D., Connolly, K., McGregor, P., & Ross, A. G. (2020). The economic and environmental impacts of UK offshore wind development: The importance of local content. *Energy, 199*, 117436. doi:https://doi.org/10.1016/j.energy.2020.117436

BBSR. (2022). INKAR – Indikatoren und Karten zur Raum- und Stadtentwicklung. Retrieved from https://www.inkar.de/

Bundesnetzagentur. (2022). *Marktstammdatenregister*. Retrieved from https://www.marktstammdatenregister.de/MaStR/Einheit/Einheiten/OeffentlicheEinheitenuebersicht

Costa, H., & Veiga, L. (2021). Local labor impact of wind energy investment: An analysis of Portuguese municipalities. *Energy Economics, 94*, 105055.

Eurostat. (2022). *Gross value added at basic prices by NUTS 3 regions*. Retrieved from https://ec.europa.eu/eurostat/web/products-datasets/-/nama_10r_3gva

Graziano, M., Lecca, P., & Musso, M. (2017). Historic paths and future expectations: The macroeconomic impacts of the offshore wind technologies in the UK. *Energy Policy, 108*, 715-730. doi:https://doi.org/10.1016/j.enpol.2017.06.042

LeSage, J., & Pace, R. K. (2009). *Introduction to spatial econometrics*: Chapman and Hall/CRC.

Mattes, A. (2014). *Die ökonomische Bedeutung der Windenergiebranche. Windenergie an Land in Deutschland und in Nordrhein-Westfalen.* Berlin: DIW Econ GmbH.

Shoeib, E. A. H., Infield, E. H., & Renski, H. C. (2021). Measuring the impacts of wind energy projects on US rural counties' community services and cost of living. *Energy Policy, 153*, 112279.

Volk, R., Stallkamp, C., Herbst, M., & Schultmann, F. (2021). Regional rotor blade waste quantification in Germany until 2040. *Resources, Conservation and Recycling, 172*, 105667.