THE IMPACT OF WIND FARMS ON PROPERTY VALUES: A GEOGRAPHICALLY WEIGHTED HEDONIC PRICING MODEL

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Overview

Wind power is the most important renewable energy source in many countries today, characterized by a rapid and extensive diffusion since the 1990s. However, it has also triggered much debate with regard to the impact on landscape and vista. Therefore, siting processes of wind farm projects are often accompanied by massive public protest, because of visual and aural impacts on the surrounding area. These mostly negative consequences might be reflected in property values and house prices. The aim of this paper is to investigate the impacts of wind farms on the surrounding area through property values, by means of a hedonic pricing model, using both a spatial fixed (viewshed) effects (accounting for spatially clustered unobserved influences) and a Geographically Weighted Regression model (accounting for spatial heterogeneity). The analysis is the first of its kind undertaken for a local region in Continental Europe (North Rhine-Westphalia, Germany). Viewsheds are calculated for each property using a digital surface model. Focusing on proximity and visibility effects caused by wind farm sites, we find that proximity, measured by the inverse distance to the nearest wind turbine, indeed causes significant negative impacts on the surrounding property values. Thereby, local statistics reveal varying spatial patterns of the coefficient estimates across and within the city areas and districts. In contrast, no evidence is found for a statistically significant impact of the visibility of the wind farm turbines.

Methods

The methodology adopted in this paper is associated with non-market valuation techniques. These comprise various techniques for estimating the value of goods and services that are not traded in markets and whose value is, therefore, not revealed in market prices (Tietenberg and Lesiw, 2009, p.35). This applies particularly to environmental goods, such as air and water quality, as well as landscape and related positive or negative externalities. The most frequently used methodology is the hedonic pricing approach. Rosen (1974) pioneered the economic formalization of a hedonic pricing model, although earlier studies tackled the approach of implicit markets (Tiebout, 1956) and statistical relationships between air quality and housing values (Ridker and Henning, 1967). According to Rosen (1974), hedonic pricing models seek to explain the overall price $p=p(x)$ of a differentiated product that is characterized by a bundle of n attributes $x = (x1,\ldots, xn)$. The hedonic function, therefore, results from the market interaction of demand and supply. Product differentiation implies the availability of alternative bundles, so that in market equilibrium p equals each consumer's bid for the differentiated product (Rosen, 1974).

In the field of environmental economics, hedonic pricing models are widely used to estimate the WTP for improvements in environmental goods, most frequently applied to the housing or property market. Houses or properties are compound products, characterized by sets of structural (e.g. house/lot size, age, and type of building), neighborhood (e.g. income distribution, crime rate, and taxes), spatial (e.g. distances to local amenities or disamenities) and environmental (e.g. noise levels, air quality, and vista) attributes.

In the framework of the hedonic pricing approach, we investigate the impacts of wind farms on the surrounding area through property values, using both a spatial fixed (viewshed) effects (accounting for spatially clustered unobserved influences), following a similar procedure proposed by Heintzelman and Tuttle (2011), and a Geographically Weighted Regression model (accounting for spatial heterogeneity).

Results

Spatial fixed effects

According to the overall model performance, we find that all four spatial fixed effects specifications perform very well with regard to the adjusted R^2 obtained. Overall, we obtained mostly consistent results across all specifications regarding the expected signs.

Regarding the wind-farm-related variables, most importantly, the inverse distance to the nearest turbine is negatively significant across all models. Therefore, a 1% increase in the inverse distance (i.e. a decrease of distance to the nearest turbine) decreases the property sales price by -.047% to -.098%.

Further, investigating the distance to the wind farm site through a set of dummy variables, negative wind farm impacts are mostly detectable in the close vicinity within the first 1.5 km around the site. Hence, within the first kilometer around the wind farm, prices decreased by 21.5% to 29.7% according to the estimations.

Based on the shadow flickering variables, the estimates hardly allow a clear interpretation. The coefficients of the shadow flickering dummy are quite diverse across the different spatial fixed effects models, ranging from -.022 to -.157. Furthermore, the estimates only became significant in two out of four model specifications.

Regarding a possible effect of announcing the wind farm project, no significance was found in any model specifications. In contrast, properties that were sold after the construction of the wind farm showed price decreases between 10.8% and 11.9%.

Geographically weighted regression

The negative impact of wind farm proximity (measured by the inverse distance to the nearest turbine) that was found in the spatial fixed effects models could be confirmed, investigating the variable using the GWR method. Additionally, we found that proximity effects vary substantially across and within the cities, contrasting the estimated results of the distance dummy variables. The investigation of the local coefficients of the visibility variable revealed that visibility has no significant impact on property values. Therefore, the results obtained in this case could not provide any validation for the relevance of applying a fixed viewshed effects model specification.

Conclusions

In order to investigate the impacts of wind farms on the surrounding area following the current public debates associated with siting processes in Germany, we applied a hedonic pricing model to the property market of the two neighboring cities Rheine and Neuenkirchen in the northern part of North Rhine-Westphalia. We investigated wind farm proximity by means of different spatial fixed effects model specifications, addressing spatial autocorrelation through spatially clustered omitted variables and spatial heterogeneity, and a local GWR model in order to further account for spatial heterogeneity caused by spatially varying relationships in the underlying data. As many hedonic pricing analyses investigating wind farm impacts focus on distance measures as a proxy for wind farm proximity, we also included variables capturing potential shadow flickering and visibility effects. We applied GIS techniques on the basis of high resolution geodata for the implementation of these variables.

According to the estimation results provided by the spatial fixed effects regressions, there is statistical evidence for a negative impact of wind farm proximity measured by the inverse distance to the nearest turbine. Various distance dummies also indicated that negative impacts are mainly limited to properties in the immediate vicinity within 1.5 km. Due to lower significance levels of the distance dummy variables, local variations of coefficients and significance levels needed further consideration. Properties that were sold after the construction of the wind farm showed lower values compared to those which were sold before, indicating a negative post-construction effect. Alternatively, the announcement of the wind farm project had no measurable influence on property prices. The results obtained for the shadow flickering variables did not allow for a clear interpretation.

The fixed viewshed effects model provided the lowest values regarding the overall model performance, although the results were largely consistent with the other models. The major insight is that absorbing potential effects of visibility, the inverse distance to the nearest turbine still remains negatively significant.

The application of the GWR revealed a more complex picture of proximity effects through the weighting of spatial relationships and local variations in the data. The negative impact of wind farm proximity that was found using spatial fixed effects could be confirmed applying the GWR method. Based on local GWR estimates, the negative effects are attributable to strong local influences of the wind farm site. Therefore, the local significance levels of wind farm distance provide evidence for a stronger negative impact in the city of Neuenkirchen than in the city of Rheine. Local coefficients and significance levels of the visibility variable revealed that visibility has no significant impact on property values. Therefore, the investigation of visibility by means of a GWR could not provide any validation for the relevance of applying a fixed viewshed effects model specification. Against this background, the results obtained by the fixed viewshed effects model remain ambiguous.

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