Regional distribution of small scale photovoltaic installations in Germany and its drivers: A spatial econometric approach

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Overview

The share of solar energy in German electricity generation has increased tremendously in recent years. This is due to guaranteed feed-in tariffs together with decreasing prices for solar panels. Small-scale PV systems that can be installed by households play a decisive part as households can contribute to the *Energiewende*, benefit from the use of renewable energy and thereby increase overall social acceptance. Several studies are focusing on factors, from social, to economic to policy incentives explaining the uptake of PV systems. Thus far studies either focus on qualitative analyses based on interviews or quantitative analyses via econometric models. These methods do not offer a framework to understand the spatial distribution of PV installations. The presented study deals with this issue by analysing the determinants of PV uptake in association with neighbouring regions. Specifically, small-scale installations ($\leq$ 10 kW_p) are evaluated. These account for more than 5 GW (14% of total PV capacity) by the end of 2015. The spatial distribution of the installed capacity is shown in Fig. 1 for the 402 German counties.

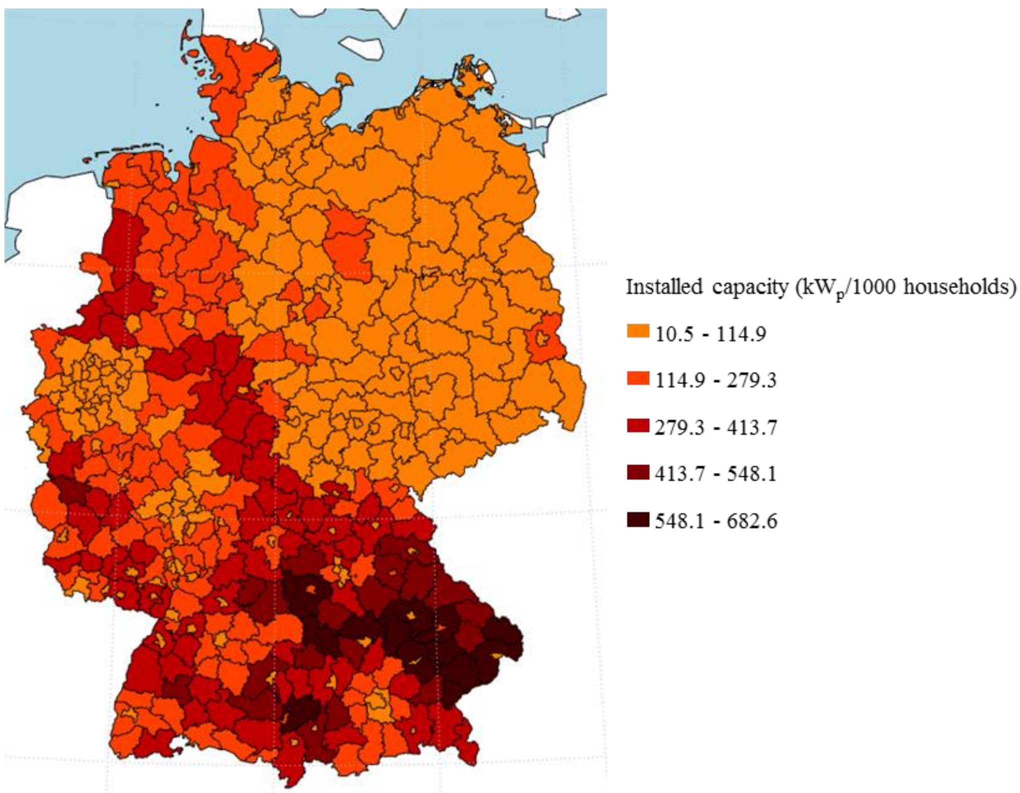

Fig. 1: Accumulated installed capacity of small-scale installations (kW_p/1000 households) in German counties by the end of 2015. Source: Own calculations and illustration based on data from Bundesnetzagentur (2016).

As the feed-in tariffs defined by the EEG are applicable in every German county, the differences in regional distribution are due to other determinants. In the literature factors like solar radiation, socio-economic factors as well as peer and neighbourhood effects are discussed (Balta-Ozkan et al. 2015; Schaffer und Brun 2015).

Methods

This study uses spatial econometrics to explain the distribution of small-scale PV installations. The following explanatory variables are taken into account: available household income, dwelling ownership rate, electricity demand, county space and solar radiation. The dependent variable as well as the explanatory variables are normalised to the number of households per county.

The analysis starts with a non-spatial standard regression (OLS) stated in Eq. 1. y is the installed capacity from small scale PV installations. X is a matrix of the standardized explanatory variables, β is a vector of standardized regression coefficients and ε is an independently and identically distributed error term with zero mean and constant variance σ^2.

$$y = X\beta + \varepsilon, \varepsilon \sim N(0, \sigma^2 I_n) \tag{1}$$

In order to explore the existence of spatial autocorrelation Moran's I is calculated. The obtained value of 0.4044 is statistically significant and indicates spatial association for accumulated PV capacity. Therefore, a spatial autocorrelation model (SAR) is specified (Eq. 2).

$$y = \rho W y + X\beta + \varepsilon \tag{2}$$

W is a spatial weights matrix which is employed to reflect the structure of potential spatial interaction. ρ is a spatial autoregressive parameter that measures the magnitude of interdependence across regions showing the effect of spatial lag in the dependent variable. In addition, different model specifications are used analysing spatial dependency in the independent variables and the error terms. These results and test statistics will be presented in the full paper.

Results

OLS and SAR estimations are performed and the results are reported in Table 1.

Table 1: Results of the OLS and SAR estimations

	OLS		SAR	
Variables	Coefficients	Standard error	Coefficients	Standard error
Available income	-0.0025	0.0452	-0.0020	0.0401
Ownership rate	0.3053***	0.0546	0.3308***	0.0484
Electricity demand	0.3350***	0.0481	0.2356***	0.0443
Solar radiation	0.3358***	0.0315	0.1785***	0.0316
County size	0.2392***	0.0398	0.2227***	0.0354
ρ (spatial autor. parameter)			0.4330***	0.0434

Signif. Codes: 0.001 '***', 0.01 '**', 0.05 '*'

Contrary to expectations, available income does not have an impact on PV installations as it is insignificant in the OLS as well as the SAR regression. The remaining explanatory variables in the OLS estimation have a positive impact on PV installations and are significant at the 0.001 level, with solar radiation having the biggest influence. The sign and significance of effects does not change in the SAR specification, but values deviate. The positive and highly significant value of the introduced spatial autoregression parameter indicates the strong influence of PV installations in one county on PV installations in neighbouring counties. These findings only serve as a first idea when analysing the regional distribution of small-scale PV and need to be investigated further.

Conclusions

The influences determining the regional distribution of PV installations are important indicators for political and scientific discussions regarding the increasing share of PV generation in Germany. In order to gain deeper insights in the possible drivers of households to install PV systems, spatial econometric models can be applied. In this study a SAR model qualifies the results of a standard OLS and examines the influence of PV installations in neighbouring counties. Other spatial model specifications are needed to verify and explain the effects in greater detail. The availability and choice of data as well as the configuration of the spatial weights matrix are crucial for the results and their interpretation.

References

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