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Social Effects in the Diffusion of Solar Photovoltaic Technology in the UK

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The determinants of new technology adoption have been addressed in the economic literature for several decades. Among others, they matter for the design of policies to promote the expansion of the respective new markets. A recent example is the market for micro-generation technologies that can be installed by households, communities and small commercial sites. The installed capacity of those small-scale installations goes up to 50kW for electricity and 300kWth for heat generation (Green Energy Act 2009). In a context of the EU target to increase the share of renewable electricity generation beyond 15 percent by 2020 and given the legally binding domestic energy policy goals to decrease national carbon emissions by 80 percent by 2050 compared to 1990, the UK government intends to encourage households to adopt micro-generation technologies and produce their own low-carbon electricity. But not only for policy design, also for economic and business reasons, the analysis of the diffusion of micro-generation technologies is particularly interesting: decentralised electricity generation has the potential to change the consumer - producer relationship, to alter the economic relations between customers and energy suppliers and to lead to new ownership and energy business models (Snape and Rynikiewicz, 2012, Watson and Devine-Wright, 2011).

So far, feed-in-tariffs (FiT) are the major instrument to promote adoption of small-scale electricity generation. In the UK they have been paid since April 2010 to mitigate the relatively high costs and uncertainties of solar PV, wind, hydro and anaerobic digestion technology. This paper focuses on solar PV technology. However, as the government's 2015 Microgeneration Strategy claims, financial incentives are not enough to guarantee sustained growth of micro-generation technologies. There are major non-financial barriers to be addressed (e.g. related to insurance and warranties or skills and knowledge). Besides those barriers, non-financial *drivers* of growth should be in focus and exploited in future policy and market strategy design towards a low-carbon decentralized electricity system. In particular, social effects from others might impact the adoption decision and hence drive diffusion. Solar PV panel installations in a neighbourhood are visible for passers-by. Observational learning from spatially close households might thus lead to a correlation of adoption decisions within neighbourhoods. If so, targeted interventions could serve as attention catching projects that could promote diffusion at lower cost than FiT.

The main research question in this paper therefore is, whether the installation rate of solar PV technology is affected by social spill-overs from spatially close households. The installed base, defined as the cumulative number of solar PV installations within a neighbourhood by the end of a particular month, serves as a measure for the social effects of interest. The analysis is based on installation data since the introduction of the FiT in April 2010. Motivated by the technology-specific time lag between the *decision* to adopt a solar PV panel and the *completion* of the installation, the third lag of the installed base serves as main regressor of interest in the panel data model employed and a first difference estimation strategy yields unbiased and consistent estimates. Further model specifications allow for a time-varying installed base effect and consider different lags of the installed base as well as different outcome variables and different geographical areas for robustness. Moreover, differences of the social effects across distinct groups of the population are analysed.

The results suggest small, but positive and significant social effects: one more solar PV panel in a postcode district increases the number of new adoptions per owner occupied households in a given month by $7.48e^{-06}$. At the average installation rate within the neighbourhoods, this is equivalent to a one percent increase in the solar PV installation rate. At the average number of 6,629 owner-occupied households within a postcode district, it implies that one more solar PV panel in the neighbourhood increases the number of new installations in the neighbourhood by 0.05. This is obviously and as expected a very small effect. It would require around 20 additional solar panels in a postcode district, for social effects alone to be strong enough to cause one further installation within the neighbourhood. The installed base elasticity at the average installed base of 68 and the average installation rate of 0.0007 (i.e. 0.7 installations per 1,000 owner-occupied households) is 0.71. These results illustrate that the social effects as measured by the installed base are very small, but exist and can promote adoption. Especially community projects that involve a high number of installations could hence promote diffusion. The social effects vary across months and overall diminish over time. Moreover, social spill-overs on the postcode district level are stronger than on a higher geographical level, the local authority level. Remarkably, relatively affluent (non-deprived) neighbourhoods show a less pronounced installed base effect. This might result from the fact that those households are early adopters and hence learning from others is less important.

The paper contributes to previous literature in performing the first econometric analysis of the diffusion of solar PV technology within the UK. It delivers empirical evidence that the adoption behaviour of others drives diffusion. The analysis is based on a remarkably recent and granular solar PV installation dataset of the UK. The results can be exploited for targeted marketing and resource allocations for the stimulation of future adoption. Nevertheless, the analysis has its limitations. Firstly, social effects are assumed to spread within defined neighbourhoods only. Spill-overs across neighbourhood borders are ignored. Spatial econometric methods, for example, could be employed to allow for more diverse spill-over effects. Another limitation is the aggregation to the neighbourhood level. Future research should make use of household level covariate data to further analyse the mechanisms underlying the adoption behaviour. Lastly, if there is inertia in the decision process, the consideration of a partial adjustment process in the model might be useful. Overall, this paper delivers a first highly disaggregated analysis of the impact of social effects on solar PV adoption in the UK that can be extended in future research.

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