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Project goals

Subsidising renewables may create a virtuous circle of adoption through the mechanisms of social contagion, which makes adoption more likely where neighbours have chosen to install a given renewable energy technology. This project aims at assessing causally the magnitude and dynamics of these peer effects in the adoption of solar energy by households and firms in Switzerland. We account for subnational differences in subsidies and make use of the *German Energiewende* as a quasi-natural experiment to test the role of social norms with respect to learning effects.

Summary

The transition towards a greener economy requires countries to switch from fossil to renewable sources of energy. This transition has proven to be difficult due to lock-in effects. Policymakers in most developed countries are trying to foster the adoption of renewable energies and, given the important resistance to the adoption of first-best instruments such as carbon taxes (cf. Thalmann 2004; Saelen and Kallbekken 2011; Baranzini & Carattini 2014; Carattini et al. 2016; Baranzini & Carattini 2017), some European countries, including Switzerland, heavily subsidize the adoption of renewable energy. This type of policy comes with important costs, which can represent hundreds of euros per ton of CO_2 abated (cf. Marcantonini & Ellerman 2014; Marcantonini & Valero 2015; Crago & Chernyakhovskiy 2017). Over the long run, however, such subsidies may create a virtuous circle of adoption through the mechanisms of social contagion, which makes adoption more likely where the installed base is larger. The international literature shows indeed that thanks to social contagion, the likelihood of adoption of solar PV is higher in neighbourhoods where the installed PV base is already important (cf. Bollinger and Gillingham 2012; Graziano and Gillingham 2015). Temporary subsidies in a given region may thus lead to a higher pace of adoption even when the financial incentive is discontinued.

This project focuses on the adoption of solar photovoltaic (PV) panels by households and firms in Switzerland. It uses spatial econometrics techniques to identify the magnitude of peer effects in the adoption of solar PV and to assess how such effects may vary in presence of policy interventions. In a second stage, we analyse how people respond to policy measures and other types of interventions, by relying on survey data and choice-experiment techniques. More precisely, we aim at:

1. Assessing the evidence of peer effects in the adoption of solar PV in Switzerland.
2. Exploiting the subnational variation in subsidies to evaluate the effect of temporary and continued subsidies.
3. Make use of the *German Energiewende* as quasi-natural experiment to test the cross-border pattern of social contagion.
4. Apply choice experiment techniques to identify the preferred attributes potentially leading to the adoption of solar PV, including the role of policy measures and other interventions.

Work undertaken and findings obtained

The first steps undertaken in 2016 consisted in reviewing the emerging literature on peer effects in the adoption of solar panels and built the database to perform points 1, 2 and 3 mentioned in the previous section. We report here the main insights from the literature review. In their seminal paper, Bollinger and Gillingham (2012) are the first to demonstrate the existence of peer effects in the adoption of solar PV systems. Using 85'046 residential PV systems in California, they show that one extra installation in the zip code increases the probability of adoption in the zip code by 0.78 percentage point. Graziano and Gillingham (2015) improve the methodology of Bollinger and Gillingham (2012) to identify the spatial dimension of peer effects, and are the first to measure the dissipation of peer effect as the time between adoptions increases. Rode and Weber (2016) also show evidence of social contagion with very large data for Germany, and bring a new empirical approach, which allow for cross-border contagion. The effects in Rode and Weber (2016) are very localized: no peer effects are found beyond 1 km from the location of the installation under scrutiny.

The main objective of point 1 of our project, is to extend the focus of the existing literature, which concentrates on residential solar PV adoption only, and assess also the behaviour of firms and farms. Additionally, we contribute to the literature by investigating in detail the impact of PV characteristics (size, type and ownership) on social spillovers.

We base our analysis on a rich dataset containing geographic location and technical information on 63'190 PV systems in Switzerland. The data, which are collected in the framework of the Swiss feed-in tariff and one-off investment subsidy, are provided by the Swiss Federal Office of Energy and cover all applications made over the years 2008-2015. We complete the database with the following socioeconomic, demographic, meteorological and built environment variables at the municipality-year level :

- Income distribution (Federal tax administration)
- Number of unemployed individuals (State Secretariat for Economic Affairs)
- Age distribution (Swiss federal statistical office)
- Green parties scores at federal elections (Swiss federal statistical office)
- Solar radiation (Federal Office for Meteorology and Climatology, MeteoSwiss)
- Building types and dwelling characteristics (Buildings and Dwellings statistic from the Swiss federal statistical office)

We shortly describe here how we built our main database, which is used to identify the magnitude and dynamics of peer effects in the adoption of solar panels. Following the standard approach in the literature, the first step consists in the computation of the individual installed bases. For each geocoded PV installation in our database, we count the number of pre-existing installations within different radius (0.333, 1, 3 and 9 km) at the time of the decision to adopt. In a second step, we create bands of installed bases by retrieving the inner circles from the outer radii. Finally, we aggregate the bands at the municipality level to obtain the mean number of neighbouring installations per band around the installations having adopted the technology during a given quarter.

Following Bollinger and Gillingham (2012) and Graziano and Gillingham (2015), our empirical model explains the number of new adoptions in a municipality during a quarter by the average bands installed bases of these newly installed PV systems. To ensure an unbiased causal identification of peer effects, we follow Bollinger and Gillingham (2012) and apply their methodology to address three well-known issues in our panel data analysis: self-selection (homophily), correlated unobservables and simultaneity. The first two issues are addressed by including municipality, quarter-canton and quarter fixed effects in the models. On top of that, we incorporate socio-economic controls and location characteristics to account for spatial and temporal heterogeneity. The issue of reflection (see Manski 1993) is slightly more complex to deal with. The solution provided by Bollinger and Gillingham (2012) relies on the important time lag between the decision to adopt solar energy and the moment of installation. This approach can be implemented with the SFOE data thanks to the information on both the day of registration and the start day of electricity generation.

Preliminary results show that decisions to adopt the PV technology in Switzerland are dependent on spatially-close, pre-existing PV systems. As expected, we observe that the distance is an important determinant of social contagion: furthest away bands have persistently lower impact on the likelihood of adoption than nearest ones. In line with Graziano and Gillingham (2015), our results also highlight that oldest nearby installations have less importance in the adoption choice than the most recently built PV systems.

Besides providing new evidence of social contagion in PV technology, this project aims to further investigate the variation of social spillovers with size, type and ownership of PV systems. Our preliminary findings suggest for instance that firms and agricultural companies react to neighbouring PV panels, although in a slightly lesser extent than households. A closer analysis seem to reveal that social contagion is primarily due to similar ownership, i.e. firms are primarily influenced by other firm-owned installations.

National cooperation

Point 2 of our project requires data about subnational subsidies for solar PV. These subsidies are provided at different administrative levels, i.e. at the municipal, cantonal, and, of course, federal level. Given this important heterogeneity, we relied on Swissolar, the association of solar energy professionals in Switzerland, which maintains an up-to-date database of most subsidies available in Switzerland as an information tool for the customers. Swissolar provided us with historical data for the years 2009 to 2015.

At our request, we also obtained specific databases from the Swiss federal statistical office (FSO) and from the Federal Office for Meteorology and Climatology (MeteoSwiss).

From an academic perspective, we note that Martin Péclat is now enrolled in the PhD programme in Economics of the University of Neuchâtel. His PhD Thesis on solar PV adoption in Switzerland is supervised by prof. Milad Zarin Nejadan, University of Neuchâtel, and prof. Andrea Baranzini, HEG Geneva.

International cooperation

Stefano Carattini is currently Postdoctoral Fellow at Yale University and part of the research group of Professor Kenneth Gillingham. Kenneth Gillingham wrote some of the seminal papers on peer effects in the adoption of solar PV in the USA and developed the methodology that we use in our project.

Outlook for 2017

The very rich database that we created allows us to perform points 1, 2 and 3 of the project. Preliminary results obtained in 2016 show that there are peer effects in the adoption of solar PV in Switzerland. Those results represent the first pillar of our project, on which we build for the continuation of our research programme. The outlook for 2017-2018 is the following:

1. Completing the assessment of peer effects in the adoption of solar PV in Switzerland. Robustness tests planned for early 2017. Preliminary version of the paper to be completed early in 2017 and submitted to the main conferences in the field for the summer conference season of 2017. Working paper version available online by the summer of 2017 (expected).
2. Completing the empirical analyses taking advantage from the particular context of Switzerland, in particular exploiting the subnational variation in subsidies to evaluate the effect of temporary and continued subsidies. See point 3.
3. Make use of the *German Energiewende* as quasi-natural experiment to test the cross-border pattern of social contagion. On top of the elements discussed on page 6, points 2 and 3 determine the novelty of this project. Points 2 and 3 build on the assessment of peer effects under point 1. The analyses on points 2 and 3 are expected to provide the first results already in 2017, and continue over 2018 for additional analyses.
4. Apply choice experiment techniques to identify the preferred attributes potentially leading to the adoption of solar PV, including the role of policy measures and other interventions. Ongoing survey design. Administration of the surveys expected for Spring 2017 and Fall 2018.

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