The Rebound Effects of Electricity Prosuming in Germany: A Matching Approach

Ayse Tugba Atasoy, Hendrik Schmitz, Reinhard Madlener
Institute for Future Energy Consumer Needs and Behavior (FCN), School of Business and Economics / E.ON Energy Research Center
RWTH Aachen University, Mathieustrasse 10, 52074 Aachen, Germany, +49 241 80 49820
TAtasoy@eonerc.rwth-aachen.de, HSchmitz@eonerc.rwth-aachen.de RMadlener@eonerc.rwth-aachen.de

Overview

Energy prosuming, which is defined as producing and consuming energy simultaneously, has become increasingly prevalent around the world, for example through the emergence of residential solar photovoltaics (PV) systems. While the technical consequences of this development are well established, little is known about behavioral changes of consumers who become prosumers. These individuals might change their behavioral patterns pertaining to energy use and energy efficiency investments due to, among other factors, changes in incentives or energy literacy and awareness. A very few studies articulate on these potential shifts in energy consumption behavior between consumers and prosumers (Schill et al. 2017, Oberst et al. 2019). Building on the scarce evidence, we design a survey questionnaire to quantify the systematic behavioral differences between consumers and prosumers. Our study aims to establish a causal link between energy prosumption and consumption by gathering representative data on both consumer segments, which then enables us to use a propensity score matching for causal inference. In our study, we explicitly focus on households that generate electricity by adopting solar PV system.

Methods

Given that observing (quasi-) experimental variation or implementing randomization is nearly impossible for "prosuming", as this implies active decisions that households undertake themselves, we identify comparable groups of prosumers and non-prosumers (i.e., consumers) by means of statistical matching techniques. Matching creates a quasi-experimental design by assigning one individual from the control group to each observation from the treatment group. The matched observations should be as similar as possible in different characteristics such as income, gender, education, housing size, housing type, and others. In this study, the prosumers are the treatment group, who are matched with the control group of consumers. There are different ways to match observations. In Propensity Score Matching (PSM), a logit model is used to estimate the probability of a household to become a prosumer. The observations are then matched based on this probability, with the best matches being the ones that are closest in probability. Alternatively, Coarsened Exact Matching (CEM) creates different bins for the confounding variables and then matches exactly on those bins. For example, age could be coarsened into strata such as 25-34 years, 35-44 years, and so on. Overall, matching aims at balancing all relevant covariates between the treatment and control groups.

Results

We hypothesize to observe systematic differences in energy consumption between consumers and prosumers. The detailed and specifically tailored survey data allows us to distinguish the financial incentives of prosuming from other behavioral factors affecting energy consumption behavior. We descriptively explore the differences between the two groups in terms of energy consumption, literacy, and awareness. After we use matching techniques, we perform standard regression methods to estimate the effect of prosuming on energy consumption. We attribute the observed differences to an effect similar to the 'rebound effect'.

Conclusions

The results obtained allow us to derive important policy implications. Ignoring rebound effects for the households who adopt solar panels might induce an overestimation of both consumer benefits (defined by the consumer surplus) and environmental benefits. Quantifying the differences between the adopters and non-adopters would be informative in terms of assessing certain subsidy schemes for prosuming and renewable energy investment schemes for households. Moreover, based on the collected data we are able to calculate the total social welfare benefit of prosuming.

References

Caliendo M., Kopeinig S. (2005). Some Practical Guidance for the Implementation of Propensity Score Matching. DIW Discussion Papers 485, DIW Berlin, April.

Oberst, C. A., Schmitz, H., & Madlener, R. (2019). Are Prosumer Households That Much Different? Evidence from Stated Residential Energy Consumption in Germany. Ecological Economics, 158, 101-115.

Qiu Y., Kahn M., Xing B. (2019). Quantifying the Rebound Effects of Residential Solar Panel Adoption. Journal of Environmental Economics and Management 96, 310-341. DOI: 10.1016/j.jeem.2019.06.003

Schill W., Zerrahn A., Kunz F. (2017). Prosumage of Solar Electricity: Pros, Cons, and the System Perspective. Economics of Energy & Environmental Policy (6)1. DOI: 10.5547/2160-5890.6.1.wsch