EMPIRICAL ESTIMATION OF THE LEVEL OF ENERGY EFFICIENCY IN THE EUROPEAN HOUSEHOLD SECTOR: EVIDENCE FROM ITALY, THE NETHERLANDS AND SWITZERLAND

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Overview

Energy efficiency has a fundamental role to play in the transition towards a more competitive, secure and sustainable energy system. EU countries have agreed on a new 2030 framework for climate and energy, including three EU-wide targets and policy objectives for the period between 2020 and 2030. These targets aim to help the EU achieve a more competitive, secure and sustainable energy system and to meet its long-term 2050 greenhouse gas reductions target. Among these three targets, there is the binding commitment to improve energy efficiency by at least 27% for the year 2030 compared to projections of future energy consumption based on the current criteria. Lately, the Commission even increased the energy efficiency target for 2030 to 30% within the new Energy Efficiency Directive.

The residential sector in European countries requires around one third of the end-use electricity. Therefore, it is important for policymakers to estimate the scope for electricity savings in households in order to reduce electricity consumption by using appropriate steering mechanisms. Moreover, it is important to know about the determinants that influence the level of efficiency in the use of electricity. A low level of efficiency, as discussed in Filippini & Hunt (2015), may be due to the fact that households do not adopt and use energy efficient appliances or do not use their appliances in an optimal way. For instance, a household might postpone substituting an old and inefficient refrigerator that consumes a lot of electricity or does not use a cooling system or washing machine in the most efficient way. The potential explanations for an inefficient use of appliances on the one hand and for an under-investment in energy-efficient household appliances on the other hand can be attributed to either market failures or behavioural failures (Broberg & Kazukauskas, 2015). Market failures that prevent investments in energy-efficient appliances can take the form of information problems (e.g., lack of information and information asymmetries), misplaced incentives and principal-agent problems such as the landlord-tenant problem. However, even if these market failures could be overcome, several behavioural failures such as bounded rationality, loss aversion, status-quo bias, risk aversion or inattentiveness potentially reduce the level of efficiency in a household's energy use.

In this paper, we provide an answer to the following questions: Which are the factors that influence the electricity demand at the household level? What is the level of efficiency in the use of electricity of European households? How large are the potentials for electricity savings in the residential sector for a given level of energy services? And is the level of efficiency in the use of electricity in these households associated with their level of energy-related financial literacy?

Methods

It is important to note that energy demand is derived from the demand for energy services within the framework of household production theory. We assume that households purchase inputs such as energy and capital (household appliances) and combine them to produce outputs which are the desired energy services such as cooked food, or washed clothes. We can, therefore, attribute a production function to this process. Following the neoclassical production framework (Farrell, 1957), we assume that households minimise the amount of inputs used in the production of a given amount of output and choose the input combination which minimises production costs. However, in practice, we observe that households may be producing energy services without minimising the use of all inputs or at least one of the inputs thereby leading to possible inefficiency in the use of electricity.

We use data collected in a large household survey, that was implemented in Switzerland, Italy and the Netherlands in 2017. The cross-sectional dataset consists of 1620 observations from Italian, Dutch and Swiss households for the year 2016. The data includes information on income, education and other socio-demographic and housing factors, appliance stock information as well as information on the amount of energy services consumed by a household. In addition, we also collected information on the level of energy-related financial literacy. Following Blasch et al.

(2018), energy-related financial literacy is the level of energy-related knowledge and cognitive abilities that consumers need to have in order to take decisions with respect to the investment for the production of energy services and their consumption. We elicit the respondents level of energy-related financial literacy using eight questions that account for several dimensions of energy-related financial literacy. Five of these eight questions tried to find out if the households know the electricity price, the electricity consumption of some appliances and the concept of risk diversification, whereas the remaining three questions were structured to collect information on the level of cognitive skills of the households in performing an investment analysis and computing the lifetime cost of an appliance.

Using this data we estimate an energy demand frontier function as proposed by Filippini & Hunt (2011) in order to estimate the level of efficiency in the use of electricity in European households. The energy demand frontier model has been estimated using the maximum likelihood estimator for cross-section data as proposed by Aigner et al. (1977).

Results

The results indicate that European households could save roughly 25-30% of their electricity usage by correcting inefficiencies. These figures are in line with recent studies from Switzerland and the US residential sector. The means of the efficiency levels are similar across countries. However, one can find differences in the standard deviations and the minimum levels of efficiencies across the countries considered.

Further, it is noticeable that respondents with a higher attainment in energy-related financial literacy score use less electricity ceteris paribus. Exploring this further, it appeared as the energy-related knowledge does not have a significant impact, whereas the level of cognitive abilities of the households in doing an investment calculation has a negative and significant effect.

Conclusions

The results clearly indicate that there is a considerable potential for saving electricity in the residential sector and thus curbing the associated CO_2 emissions, Furthermore, the electricity saving potential appeared to be relatively homogenous on average in the European countries considered. The level of inefficiency is partially due to consumers that do not adopt energy efficient appliances or do not use their appliances in an optimal way. In order to decrease these inefficiencies in the use of electriciy, policymakers might consider promoting the level of energy-related financial literacy through educational programs or introducing instruments such as reliable lifetime cost calculators for appliances.

References

Aigner, D., Lovell, C. A. K., & Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, *6*(1), 21–37.

Blasch, J., Boogen, N., Daminato, C., & Filippini, M. (2018). *Empower the consumer! Energy-related financial literacy and its socioeconomic determinants* (Working Paper). CER-ETH - Center of Economic Research at ETH Zurich.

Broberg, T., & Kazukauskas, A. (2015). Inefficiencies in Residential Use of Energy — A Critical Overview of Literature and Energy Efficiency Policies in the EU. *International Review of Environmental and Resource Economics*, *8*(2), 225–279.

Farrell, M. J. (1957). The Measurement of Productive Efficiency. *Journal of the Royal Statistical Society*, *120*(3), 253–290.

Filippini, M., & Hunt, L. C. (2011). Energy Demand and Energy Efficiency in the OECD Countries: A Stochastic Demand Frontier Approach. *The Energy Journal*, *32*(2), 59–80.

Filippini, M., & Hunt, L. C. (2015). Measurement of energy efficiency based on economic foundations. *Energy Economics*, *52*, S5–S16.