THE ROLE OF ENERGY AND INVESTMENT LITERACY FOR RESIDENTIAL ELECTRICITY DEMAND AND END-USE EFFICIENCY

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Overview

Improving efficiency in the use of energy is an important goal for many nations since end-use energy efficiency can help to reduce CO_2 emissions. Furthermore, since the residential sector in industrialised countries requires around one third of the end-use electricity, it is important for policy makers to estimate the scope for electricity saving in households to reduce electricity consumption by using appropriate steering mechanisms. Moreover, it is important to know which are the determinants that influence the level of efficiency in the use of electricity. A low level of efficiency, as discussed in Filippini and 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 can be attributed to either market failures or behavioural failures (Broberg and 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. But even if these market failures could be overcome, several behavioral 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. All these behavioral failures tend to prevent households from identifying the appliances that minimize lifetime costs or from using the appliances in an efficient way. On the contrary, as shown by Blasch et al. (2016), households that are scoring high with respect to investment and energy literacy seem to be less prone to boundedly rational behaviour.

To our knowledge, relatively few studies have looked into the relationship between energy and investment literacy and residential energy efficiency (for an example, see Brounen et al. (2013)). Investment literacy can be defined as the ability to perform an investment analysis and to calculate the lifetime cost of an appliance or energy-efficient renovation. Energy literacy can be defined as an individual's cognitive, affective and behavioral abilities with respect to energy-related choices. According to DeWaters and Powers (2011), energy literacy comprises an individual's or household's (1) knowledge about energy production and consumption as well as its impact on the environment and society; (2) attitudes and values towards energy conservation; and (3) corresponding behaviour. In this paper, we therefore put particular emphasis on examining the influence of energy literacy, investment literacy and energy-saving behavior on a household's level of efficiency in the use of electricity.

Hence, 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 Swiss households? How large are the potentials for energy savings in the residential sector for a given level of energy services? Does a household's level of energy and investment literacy influence its level of efficiency in the use of electricity?

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.

This paper estimates the level of transient and persistent efficiency in the use of electricity in Swiss households. In the context of a household, the persistent inefficiency component might relate to the presence of structural problems in the production process of energy services like old electrical appliance stock or old buildings with very poor insulation. It might also relate to systematic behavioural shortcomings like frequently opening the windows and not switching off lights after use. Similarly, the transient inefficiency part might point towards the presence of non-systematic behavioural failures that could be solved in the short term, e.g., the use of an additional cooling appliance for a few weeks during a hot summer, hence increasing the demand for energy services temporarily. We use the newly developed generalized true random effects model (GTREM) (Colombi et al., 2014; Filippini and Greene, 2016). In addition, a panel dataset of 1, 994 Swiss households from 2010 to 2014 collected via a household survey is used to estimate an electricity demand frontier function, where we control for income, eduction and other socio-demopraphic and housing factors. We further investigate whether energy and investment literacy have an influence on the household electricity consumption.

Results

Our models show that electricity consumption increases with dwelling size and single family houses have higher electricity consumption than households living in apartments. Compared to the buildings built before 1940, newly built houses generally consume lower electricity, with the exception of those built between the years 1970 and 2000. Electricity consumption also increases with household size. Households, in which elderly people of 60 years or older are present, tend to consume more electricity, whereas households with children consume less. Income levels are found to be less significant when accounting for all other variables. Furthermore, the short-run or the transient part of the efficiency in residential electricity consumption is found to be between 63.4% and 97.4%, with a mean value of about 89.2%. The long-run component representing the persistent part of the efficiency ranges from 39.4% to 84.1% and has a mean value of 78.4%.

We further investigate if energy literacy, investment literacy and energy-saving behaviour have an influence on the household electricity consumption. We construct a score on energy literacy, a binary variable for investment literacy, and an index that aggregates several energy saving behaviours and included these in our GTREM specification. The results show that for households exhibiting energy saving behaviour, electricity consumption is seen to be lower. Similarly, households possessing a higher energy literacy or investment literacy are also associated with lower electricity consumption.

Conclusions

Our results indicate a considerable potential for electricity savings and thus reaching the reduction targets defined by the Swiss federal council as part of the Energy Strategy 2050, wherein end-use efficiency improvement is one of the main pillars. The models show significant inefficiencies in the use of electricity among Swiss households, both transient (11%) and persistent (22%). Persistent efficiency is observed to be lower both in terms of the mean value and the variance, implying higher long-run inefficiencies. This high value of inefficiency is indicative of structural problems faced by Swiss households, who probably rely on an old appliance stock within their homes. Moreover, this also possibly points to systematic behavioural shortcomings in terms of consumption of energy services.

Moreover, the results support a positive role of energy and, in particular, investment literacy in reducing household electricity consumption. Policies that target an improvement of energy literacy, investment literacy and promote energy-saving behaviour among the Swiss population could help in improving efficiency in the use of energy within households, which could prove much more beneficial in the long run. Finally, we emphasize again that clear distinction has to be made between the persistent and transient inefficiencies faced by households in order to appropriately channel the relevant policy measures. For instance, energy policy measures that try to promote energy saving (such as an information campaign) or try to increase the level of energy literacy (such as distribution of information leaflets and booklets among households) will probably have an impact on the level of transient efficiency. On the other hand, policy measures that try to improve the level of investment literacy, such as short courses training individuals in assessing investments, could have an impact on the buying process of appliances, and therefore, on the level of persistent efficiency.