ESTIMATING THE POTENTIAL FOR ELECTRICITY SAVINGS IN HOUSEHOLDS

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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.

McKinsey & Company (2009) have estimated the potential for energy savings for all end-uses, except transport, in the US. They apply an economic-engineering approach based on bottom-up models. They predict energy saving in 2020 in the residential sector to be 25-30%. Prognos (2011) estimate the potential for energy saving in Switzerland similar to McKinsey & Company (2009). They find that the electricity consumption for households can be reduced by almost 15% by 2035 and 20% by 2050 compared to the reference scenario. In such economic-engineering models the researcher has to make assumptions on the future technology. This paper, on the other hand, follows a top-down approach using stochastic frontier analysis based on micro- economic production theory to measure the level of technical efficiency in the use of electricity in Swiss households. This approach uses a relative technology benchmark, which is given through the sample. As some households in the sample have newer appliances and technologies at home, we measure the potential of electricity saving using today’s technology. In this way, we can estimate this potential independent of assumptions on future technologies.

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.

Productive efficiency in a microeconomics framework is traditionally measured in a radial way, meaning that the focus is on the efficiency of all inputs used in the production process. However, in this paper, we are only interested in the efficiency in the use of one of the inputs, namely electricity. In this context the concept of input-specific efficiency in the use of an input introduced by Kopp (1981) is useful. As we discuss later in more detail, there are several approaches within the production theory to measure input-specific efficiency. We follow an approach, similar to Zhou et al. (2012), that estimates a sub-vector electricity distance frontier function using stochastic frontier analysis (SFA).

We use a survey of residential electricity demand conducted on Swiss households in 2005 and 2011. The data include information on appliance stock as well as information on the amount of energy services consumed within a household such as the number of meals consumed, hot water, entertainment, lighting and washing. Therefore, we are able to estimate a sub-vector input distance function, similar to Zhou et al. (2012), but using household survey data. Thus, to the best of our knowledge, this is the first study that includes energy services in the frontier model and adopts a distance function approach on a disaggregated level to estimate the level of technical efficiency in the use of electricity based on a microeconomic foundation.

Results

We find an average inefficiency in electricity use by Swiss households of around 20%. Bottom-up economic-engineering models estimate the potential in Switzerland to be around 15% to 20%. In this paper we use a sub-vector input distance frontier function based on economic foundations. Our estimates lie at the upper end of the electricity saving potential estimated by the afore-mentioned economic-engineering approach. Further, we investigate in an explorative way if standby reduction practices have an influence on the inefficiency level in the use of electricity. We use an index that aggregates different standby practices and the empirical results show, that the standby reduction practices seem to reduce the inefficiency level.

Conclusions

From the point of view of policy makers we conclude that there is considerable potential for improving the efficient use of electricity in some households.

Lastly, we should note that households are very diverse and there may exist significant unobserved heterogeneity that we cannot account for in this paper. However, this can be solved by using panel data in future work combining the approach used in this paper and the approach by Alberini and Filippini (2015).

References

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