A STRUCTURAL ANALYSIS OF THE DIRECT AND INDIRECT REBOUND EFFECTS IN RESIDENTIAL HEATING

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Overview

Promoting energy efficiency is the first pillar of the energy strategy 2050 in Switzerland, with buildings and heating systems being one major target. Yet the available empirical literature provide no conclusive result about the households' responses to such improvements, i.e. "rebound effects". There is a great discrepancy in the reported estimates of rebound effects. More importantly, most available studies are reduced-form analyses that do not account for endogeneity biases. Finally, there are few studies that have addressed the micro-level direct and indirect rebound responses together. Focusing on residential heating, we study how the households react to a gain in energy efficiency. They may adapt (increase) their demand because the relative price of the energy service has diminished thanks to the efficiency gains. An increased demand for the heating service is the direct rebound effect, while the indirect rebound effect is the impact on the energy requirement embodied in the consumption of all other goods and services. Both effects take back some of the global energy savings initially expected. As efficiency is seen as a key tool to decrease our energy consumption and in turn our CO_2 emissions, a reliable estimation of rebound effects is crucial for energy policy.

The aim of this paper is to estimate the rebound effects with a cross-sectional data from Switzerland. The econometric model accounts for the simultaneity of the household decision in adopting the efficiency level and its demand for energy services. We also analyze the variation in rebound responses according to a selection of socio-economic characteristics, in order to explore deeper the mechanisms and motives underlying the rebound effects. The results will be also used to assess the validity of a preliminary estimation of rebound effects using a hypothetical choice experiment, reported in a previous study by these authors. The two complementary studies will provide important insights as to whether and how stated preferences methods could be used to elicit micro-level rebound responses in a reliable manner.

Methods

The dataset is a cross-section of about 3,500 Swiss households with various variables on energy consumption at the household level, including variables on the heating system and the heating bill. This survey had a follow-up survey with a variety of socio-economic variables as well as some psychological and sociological items.

An important challenge to identify correctly the rebound effects is the possible endogeneity of the adopted efficiency improvement. The selection of intensive users to higher efficiency levels could bias the estimates of the direct rebound effect. To the extent that the household's efficiency investment and its consumption of all goods and services are a result of simultaneous decisions, any reduced regression model that includes the adopted efficiency level as an explanatory variable, is subject to endogeneity bias. This implies that an adequate modeling of indirect rebound effects should account for endogeneity as well. In other words, the efficiency of the technology depends in part on the preferred service level. The idea is that if someone values highly his heating comfort (with for example a high indoor temperature), he will probably choose a house with an efficient heating system to diminish the operating costs. In this case the OLS estimate of the direct rebound effect could be biased. To take into account this bias, we use a simultaneous equations model that is estimated by the 3SLS method:

Ln(heating efficiency) = f (heating costs and household characteristics)
Ln(heating costs) = g (heating efficiency and household characteristics)
Ln(embodied energy of a selection of consumption goods) = h (heating efficiency and household characteristics)

The direct rebound effect is calculated through the elasticity of heating costs with respect to heating efficiency. The last equation captures the indirect rebound effect: with a more efficient heating system, you will save some money on your heating bill, and use this money to purchase goods or services. As any product and service requires energy to be created and used (embodied energy), the overall energy consumption will decrease by less than the amount predicted by the renovation of your heating system, even in the absence of any direct rebound effect.

Results

A first analysis using stated preferences gives on average a direct rebound effect of 12% and an indirect rebound effect of 25%. It means that about one third of the expected energy savings after an improvement of the efficiency of the heating system are lost. A strong heterogeneity exists among household, with about half of them showing no direct rebound effect. With the system of equations we will test if the results are consistent using revealed data.

Conclusions

Knowing the magnitude of rebound effects for residential heating is important to plan and forecast correctly the effects of energy transition policies in this sector. We show that about one third of the expected energy savings are lost after an efficiency gain. Fortunately a third is far from the backfire situation (a rebound effect of more than 100%), a counterproductive situation in which the households end up using more energy after the efficiency improvement than before.

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