REBOUND EFFECT FOR HOUSEHOLD ENRGY SERVICES IN THE UK

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Overview

Improved energy efficiency is widely expected to play a key role in reducing energy consumption and GHG emissions. However, the energy and emissions savings from such improvements may be less than simple calculations suggest, owing to a variety of economic mechanisms that go under the heading of *rebound effects* (Sorrell 2010). *Direct* rebound effects result from increased consumption of relatively cheaper energy services: for example, an efficient boiler lowers the cost of space heating so households may choose to increase the home temperature and/or leave the heating on for longer hours. *Indirect* rebound effects result from changes in consumption of other goods and services, the provision of which necessarily involves energy use and GHG emissions. For example, lower cost of space heating may be put towards lighting. Re-spending therefore may lead to additional energy use and emissions, which offset the original energy and emission savings. Energy efficiency improvements lead to both direct and indirect rebound effects and in combination they may be significant (Chitnis et. al. 2013, 2015). This study estimates the direct and indirect rebound effects following energy efficiency improvements that affect household 'energy services': lighting, space heating, water heating, appliances and cooking by an average UK household. The study departs from the previous papers by quantifying the rebound effects for individual *'energy services'* rather than *'energy'* using the data on efficiency of each energy service.

Methods

This study estimates a linear Almost Ideal Demand System (AIDS) of Deaton & Muellbauer (1980) incorporating *'efficiency'* of energy services mentioned above through the price of these energy services:

$$w_{it} = \alpha_i + \sum_j \gamma_{ij} \ln p_{jt} + \beta_i \ln(x_t / P_t) + \sum_j \lambda_{ij} w_{jt-1} + \varepsilon_{it}$$

Where w_i is the budget share of energy service *i*, p_i is the price of energy service *i*, x_t is the total expenditure for energy services and P_t is the Stone price index. α_i is the constant term, γ_{ij}, β_i and λ_{ij} are unknown parameters and ε_{it} is an error term. Our model departs from standard applications of LAIDS by including lagged expenditure shares w_{jt-1} to capture the inertia in price responses e.g. as a result of habit formation. The inclusion of lags also reduces problems of serial correlation (Edgerton 1997). The following restrictions are imposed to the model:

Adding up: $\sum_i \alpha_i = 1$; $\sum_i \beta_i = 0$; $\sum_i \gamma_{ij} = 0$; and $\sum_i \lambda_{ij} = 0$

Homogeneity: $\sum_i \gamma_{ij} = 0$ and Symmetry: $\gamma_{ij} = \gamma_{ji}$

The model is estimated by econometrics approach of Iterative Seemingly Unrelated Regressions (ISUR). The data are annual time series 1970-2013 for UK households. In particular, we construct the efficiency data (used to compute the price of individual energy services) based on various sources. Following Edgerton 1997, from this we obtain own-price, cross-price and expenditure elasticities for individual energy services. Direct rebound is estimated as the negative of own- price elasticity of each Energy Service. Indirect rebound effects will be estimated using the above elasticities and GHG intensities for energy services in order to present the rebound both in terms of energy and GHG (rebound in energy and GHG terms are equal for direct rebound).

Results

The preliminary results, assuming total expenditure on energy services remain constant, show a *'direct'* rebound effect from energy efficiency improvement of 118% for lighting, 72% for space heating, 70% for water heating, 92% for appliances and 120% for cooking. It is expected that rebound effects would be lower when allowing for changes in total expenditure for energy services (but still relatively large in magnitude).

Conclusions

The results indicate how the rebound effect varies with the type of energy efficiency improvement. Rebound effects appear to be relatively lower for measures that improve the efficiency for space heating, water heating and appliances but significantly larger for measures that improve lighting and cooking efficiencies (backfire). Moreover, we expect that adding indirect rebound will increase the estimated rebound effects even more. Overall, the results demonstrate the importance of taking account of rebound effects when estimating the impact of energy efficiency improvements in policy-making.

References

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