REBOUND EFFECT FOR PRIVATE TRANSPORT AND ENERGY SERVICES IN THE UK

Mona Chitnis, Surrey Energy Economics Centre (SEEC), School of Economics, Faculty of Arts and Social Sciences, University of Surrey, Guildford, GU2 7XH, UK, Tel. +44 (0) 1483 689923, Email: m.chitnis@surrey.ac.uk
Roger Fouquet, London School of Economics and Political Science, Tel. +44 (0) 207 1075027, Email : r.fouquet@lse.ac.uk
Steve Sorrell, University of Sussex, Tel. +44 (0) 1273 877067, Email: s.r.sorrell@sussex.ac.uk

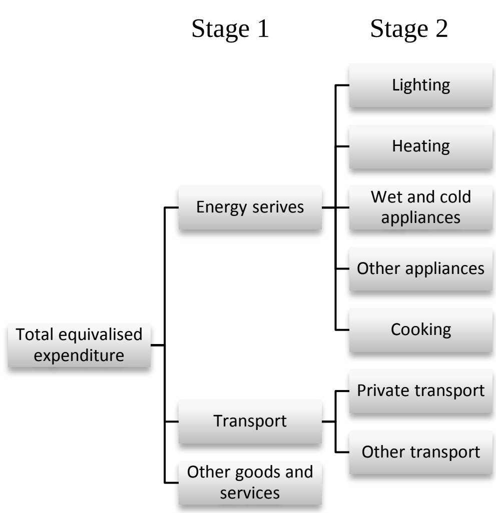
Overview

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 internal temperatures and/or leave the heating on for longer. *Indirect* rebound effects result from induced changes in consumption of other goods and services, the provision of which necessarily involves energy use and GHG emissions. For example, the money saved on space heating may be spent instead on increased lighting, or on electronic appliances. Re-spending therefore may lead to additional energy use and emissions, which offset the original energy and emission savings.

This study estimates the direct and indirect rebound effects following private transport and residential energy efficiency improvements for UK equivalised person. Using a unique dataset, the study separately investigates the effect of efficiency improvements for lighting, heating (water and heating combined), wet and cold appliances, other electrical appliances, cooking and transport. This is the first study to investigate rebound effect at this level of disaggregation. The study includes the indirect rebound effects that result from increased consumption of other energy services (e.g. cheaper heating leading to more lighting), but excludes embodied energy.

Methods

A two stage budgeting model is assumed as follow:



A linear Almost Ideal Demand System (AIDS) of Deaton & Muellbauer (1980) is estimated for each stage of the model; incorporating '*efficiency*' of energy services mentioned above through the price of these energy services:

$$w_{it} = \alpha_i + \sum_j \gamma_{0ij} \ln p_{jt} + \sum_j \gamma_{1ij} \ln p_{jt-1} + \sum_j \gamma_{2ij} \ln p_{jt-2} + \beta_{0i} \ln(x/P)_t + \beta_{1i} \ln(x/P)_{t-1} + \beta_{2i} \ln(x/P)_{t-2}$$

$$+ \sum_j \lambda_{1ij} w_{jt-1} + \sum_j \lambda_{2ij} w_{jt-2} + \delta_i hdd_t + \theta_i t + \varepsilon_{it}$$

Where w_i is the budget share of energy service *i*, p_i is the price of energy service *I* (energy price divided by efficiency), x_t is the total equivalised expenditure for energy services, P_t is the Laspeyres equivalent of the standard Stone price index, hdd_t is the heating degree days and *t* is the time trend. α_i is the constant term, γ_{ij} , $\beta_i, \lambda_{ij}, \delta_i$ and θ_i are unknown parameters and ε_{it} is an error term. The model in this study departs from standard applications of LAIDS by extending it to a general Autoregressive Distributed Lag (ARDL) model starting with two number of lags and dropping the insignificant variables. The inclusion of lags generally reduces problems of serial correlation. In addition, weather (hdd) and trend (t) variables are included in the model. Furthermore, to avoid the endogeneity problem caused by the use of standard Stone price index, we use a Laspeyres equivalent of the index. The following restrictions are imposed to the model:

Adding up: $\sum_i \alpha_i = 1$; $\sum_i \beta_{ni} = 0$; $\sum_i \gamma_{nij} = 0$; $\sum_i \lambda_{nij} = 0$; $\sum_i \delta_i = 0$ and $\sum_i \theta_i = 0$

Homogeneity: $\sum_i \gamma_{nij} = 0$ and Symmetry: $\gamma_{nij} = \gamma_{nji}$, *n*=0, 1, 2

The model is estimated by econometrics approach of Iterative Seemingly Unrelated Regressions (ISUR). The data are annual time series for 1964-2015, derived from a variety of sources with estimates of average energy efficiency being used to derive the price of the individual energy services. From the estimated model, we obtain own-price, cross-price and income elasticities for each energy service based on Edgerton 1997 elasticities for two stage budgeting system. The direct rebound effect is estimated from the negative of the own- price elasticity of each energy service, while the indirect rebound effects are estimated from the cross-price elasticities and the relevant energy and GHG intensities. Rebound effects are estimated in terms of GHG emissions.

Results

The initial results suggest a *direct* rebound effect from energy efficiency improvement of 94% for lighting, 65% heating and about 90% for wet and cold appliances, other electrical appliances and cooking. Indirect rebound effects are -57% for lighting, -34% heating, -53% for wet and cold appliances and other electrical appliances and -51% for cooking. This means that total rebound effects for lighting, wet and cold appliances and other electrical appliances is 36%, for heating is 31% and for cooking is 39%. We are further investigating the robustness of these results by re-formulating the model (e.g. combining the appliances) and additional tests. The rebound effect for transport is still to be estimated. In order to understand the importance of estimating the rebound effect based on an 'energy service' demand; we will repeat the estimation based on an energy demand model and compare the results with above.

Conclusions

The results indicate how the direct and indirect rebound effects vary with the type of energy efficiency improvement. Rebound effects appear to be relatively lower for measures that improve the efficiency for heating but significantly larger for measures that improve lighting, appliances and cooking efficiencies. We expect that adding transport will affect the estimated rebound effects significantly. We also expect that rebound based on energy demand model to be significantly different from above results. These results are subject to a number of caveats, and further elaborations of the model (to be incorporated into this paper) may modify our estimates.

Overall, because rebound is less than 100%, the energy-saving measures are still worthwhile. In addition, 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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