DOES ENERGY EFFICIENCY REDUCE GHG EMISSIONS? EVIDENCE FOR UK HOUSEHOLDS

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Overview

Policymakers expect improved energy efficiency to play a key role in reducing GHG emissions. However, the energy and emissions savings from such improvements may be less than simple calculations suggest, owing to a variety of mechanisms that go under the heading of *rebound effects* (Sorrell 2010).

Direct rebound effects result from increased demand for relatively cheaper energy services: for example, insulation lowers heating costs and encourages households to heat their homes for longer and/or to higher temperatures. *Indirect* rebound effects result from higher demand for other (normal) goods and services as a result of increased real household income: for example clothes that are manufactured in China and shipped to the UK. Energy efficiency improvements, such as loft insulation, lead to both types of effect, while sufficiency measures such as lowering the thermostat lead only to indirect effects. In combination, they can be significant (Chitnis et. al. 2013).

In this paper, we simulate a number of energy efficiency improvements and sufficiency measures by UK households and estimate the resulting direct and indirect rebound effects. The measures considered include insulation improvements, efficient boiler, energy efficient lighting, fuel-efficient cars, lowering the thermostat and walking instead of driving. We explore how rebound effects may vary for the above measures, and investigate how allowing for the 'embodied GHGs' of the relevant measure can affect the results obtained.

Methods

First, assuming three stage budgeting similar to Brannlund (2007), we estimate a linear Almost Ideal Demand System (AIDS) following Deaton & Muellbauer (1980), using UK household time series data for 1997Q1 to 2012Q1. The model is estimated by Iterative Seemingly Unrelated Regressions (ISUR):

$$w_{it} = \alpha_i + \sum_j \gamma_{ij} \ln p_{jt} + \beta_i \ln(x_t / P_t) + \varepsilon_t \quad \varepsilon_t \sim NID(0, \sigma_\varepsilon^2)$$

Where w_i is the budget share of commodity i, p_j is the price of commodity j, x_t is the total expenditure and P_t is the Stone price index. α_i is the constant term, γ_{ij} and β_i are unknown parameters and ε_t is an error term.

Second, we assume a decrease in relevant energy price from the different measures (equal to an increase in energy efficiency) and estimate the changes in expenditure for different categories of goods and services. We then calculate the implications for GHG emissions and use these to estimate the rebound effects averaged over a period of ten years. In doing this we disaggregate the substitution and income effects in order to estimate the contribution of each of these effects in forming total rebound effects. We estimate the rebound effects as:

$$R_t = \frac{\Delta G_t + \Delta M_t}{\Delta H_t}$$

Where R is the rebound effect, ΔG is the changes in GHG emissions due to substitution and income effects, ΔM is the embodied effect and ΔH is engineering effect (or expected reduction in GHG emissions). Our calculations combine estimates of the GHG intensity and own-price elasticity, cross-price elasticity and expenditure elasticity of different categories of household goods and services. The GHG intensities for different categories of goods and services are derived from an environmentally extended input output model (Druckman and Jackson 2009). We also count for embodied GHG emission associated to each energy efficiency measure.

Results

We expect the results to be as follows:

- If the embodied GHGs of the relevant measures are ignored, we expect 'heating' and 'lighting' measures to have an average rebound effect of around 15%, while the 'transport' measures to have an average rebound effect of around 30%.
- Additionally allowing for embodied GHGs of the relevant measures will increase the average rebound effect for the 'heating' and 'lighting' measures to around 17%.

Conclusions

Our results will show that the magnitude of the rebound effect varies according to the actions taken, depending upon the embodied GHGs involved. Rebound effects are expected to be relatively moderate for measures to improve 'heating' and 'lighting' efficiency, but to be significantly larger for measures to improve transport efficiency. This difference would result from the lower GHG intensity of expenditure on vehicle fuels relative to expenditure on gas or electricity.

Even though we expect to have a rebound effect, we anticipate that because it would be generally less than 100%, the energy-saving measures are still worthwhile. Overall, our results will demonstrate the importance of taking account of rebound effects when estimating the impact of energy efficiency measures in policy-making.

References

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