ENERGY EFFICIENCY AND THE REBOUND: ESTIMATING INCOME AND SUBSTITUTION EFFECTS

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Overview

Improved energy efficiency is widely expected 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 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, a fuel efficient car lowers the running costs so people may choose to drive further and/or more often in their fuel-efficient car. *Indirect* rebound effects result from increased consumption of other (normal) goods and services, the provision of which necessarily involves energy use and GHG emissions throughout their life-cycle. For example, any savings on petrol bills may be put towards a foreign holiday, or towards the purchase of a laptop that was manufactured overseas. Re-spending therefore leads to additional energy use and emissions, either within the national economy or overseas, 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). This study estimates the combined direct and indirect rebound effects following energy efficiency improvements that affect electricity, heating fuels and road fuel demand by an average UK household. Rebound effects are estimated in GHGs terms. The study departs from the previous papers by quantifying both the *income and substitution effects*.

Methods

This study uses annual time series data for UK household and estimates a linear Almost Ideal Demand System (AIDS) of Deaton & Muellbauer (1980) assuming two-stage budgeting model. The econometric estimation procedure employs Iterative Seemingly Unrelated Regressions (ISUR). The rebound calculations combine estimates of the GHG intensity (Druckman and Jackson 2009) and own-price, cross-price and income elasticities for different categories of household goods and services following Edgerton 1997. The Slutsky equation is used to estimate the relative contribution of substitution and income effects to the total rebound effect.

Results

The preliminary results show a rebound effect, from energy efficiency improvement, of 20% for measures affecting heating fuels, 18% for measures affecting electricity and 38% for measures affecting road fuels. In all cases, the income effect provides the largest contribution to the total rebound effect. While the income effect for efficiency improvements affecting heating fuels and electricity are relatively moderate (15-17%), the improvements affecting road fuels have significantly larger rebound from income effects (37%) because re-spending on gas, with relatively high GHG intensity, has a significant contribution to income effect for this category. For both the substitution effect and the overall rebound effect direct emissions (energy categories) are larger than embodied emissions (non-energy categories) for efficiency improvements affecting heating fuels and electricity but embodied emission dominate the improvements affecting road fuels.

Conclusions

The results indicate how the rebound effect varies with the type of energy efficiency improvement. Rebound effects appear to be relatively moderate for measures that improve heating and electricity efficiency, but significantly larger for measures that improve road fuel efficiency. This difference largely results from the lower GHG intensity (in tCO_2/£) of expenditure on road fuels relative to expenditure on gas or electricity. Even though there is a rebound effect, because it is generally less than 100%, the measures improving energy efficiency are still worthwhile. 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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