Considering the Welfare Impacts of Energy Efficiency and Rebound

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Overview

Improving energy efficiency is widely accepted as one of the most cost-effective means to reduce CO_2 emissions through reduction in fossil fuel energy consumption (IEA, 2014a). However, the benefits are not limited to energy and greenhouse gas emission savings. There are other considerable benefits from improving energy efficiency that are now being coined the 'multiple benefits of energy efficiency' (IEA, 2014b). These benefits extend from individual level to regional and national level and across economic, social and environmental outcomes.

Notwithstanding this, the merit of energy efficiency as a mitigation measure is regularly called into question with allusions to the 'rebound effect'. Rebound occurs when the realised reduction in energy demand is less than the engineering estimates predict, because of price and income effects occurring directly or indirectly in different areas of the economic system.

The research question in this paper is whether energy efficiency rebound effects are in fact welfare-enhancing from a societal perspective. We go a step further and propose that without rebound, the benefits of energy efficiency would be limited to the single vector of energy use.

Energy efficiency, rebound effects and welfare

A multiple benefits perspective on energy efficiency improvements contextualises them within a wider system of impacts where energy demand reduction is but one vector of many outcomes. While all are driven by the energy efficiency measure, some of these some economic and social benefits imply increased energy consumption overall and could therefore be seen as synonymous with the resulting rebound effects.

The relationship between rebound effects and welfare is an important subject in the context of the highly contentious recent media debate around the potential rebound effects associated with energy efficiency measures (Revkin, 2014). A significant part of the literature on energy efficiency rebound effects deals with classifying and estimating the rebound effects (Turner, 2013). Several papers acknowledge that the rebound effect is likely to have positive welfare implications (Gillingham et al., 2014, Borenstein, 2015). Chan and Gillingham show that when the externalities or other costs associated with increased energy use (i.e. the rebound effect) are lower than the benefits from increased energy use, then the rebound effect is welfare enhancing. However there is little analysis and few examples of explicit estimations of the welfare implications of rebound in the literature.

EE improvement	GDP	HH consumption	Employment	HH energy consumption	Total energy demand	Rebound
5%	0.10%	0.25%	0.10%	-1.62%	-0.70%	59.3%
5% (Cost of living reflected in lowr wage demands)	0.24%	0.29%	0.25%	-1.59%	-0.62%	63.9%

Table 1: Macroeconomic impacts of 5% energy efficiency improvement in UK household sector

Results

In this paper, we present some illustrative results of the macroeconomic and microeconomic welfare impacts of the rebound effect associated with an increase in energy efficiency in the (UK) household sector. Because fuel poverty remains a major societal challenge in the UK, we also examine the distributive effects of these rebound effects in the household sector.

The first part of these results is based on a paper by Lecca et al (2014) - one of the few economy-wide modelling studies that considers the impact of energy efficiency improvements on energy demand with a range of macroeconomic indicators and considers the rebound effect this engenders. They use a CGE model with 21 industries, including four energy supply sectors (coal; oil and nuclear fuels; gas; electricity) and an aggregate household sector.

The model results suggest that a 5% improvement in efficiency in household

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energy use (introduced as a costless public good in order to focus on the response to the pure efficiency effect) would have positive effects on the national economy (Table 1). In this case, if we compare the value of an increase of 0.1% GDP (£1713.9 million in 2013) with the value of the energy not saved as a result of the rebound effect (£526.8 million), it appears a priori that the net rebound effect is welfare-increasing.

Policy makers concerned with fuel poverty will question the impact of these welfare effects at a microeconomic level on different household income groups. To answer this question, we have run an illustrative simulation using Lecca et al's model[1], but focussing on an improvement in the efficiency of electricity and gas use in household heating and lighting, as these are are the main concern in a fuel poverty context. We do not simulate a change in efficiency in the fuel use involved in running private cars, but this could be one area where households decide to reallocate income savings. The results are presented in Table 2 for UK households broken into income quintiles, with the lowest household income group identified as HH 1. There we focus, for electricity and gas in turn, on what happens to (a) overall household expenditure on physical energy (taking the impacts of full economy-wide adjustment into account); (b) this spend as a share of total income (as an indicator of whether the degree of 'fuel poverty' rises or falls); (c) total household rebound in this energy use (which equates to (a) and, again, is not limited to direct rebound).

	Change in household electricity use (%)			Change in household gas use (%)		
	Overall	As share income	Total rebound	Overall	As share income	Total rebound
HH 1	-3.02	-3.17	39.69	-3.01	-3.17	39.72
HH 2	-3.51	-3.66	29.76	-3.51	-3.66	29.79
HH 3	-3.27	-3.42	34.70	-3.26	-3.42	34.73
HH 4	-3.04	-3.19	39.23	-3.04	-3.19	39.26
HH 5	-2.90	-3.06	41.91	-2.90	-3.05	41.94

Table 2: Impacts on electricity and gas use in different household income quintiles from 5% increase in the efficiency of use of both fuels

The results in Table 2 indicate that the lowest and highest income groups rebound the most in their use of electricity and gas, due to a combination of energy intensity (with lower income groups spending a larger share of their income on energy) and the strength of income effects (where higher income households have a greater share of their income deriving from returns to labour and capital).

The key result in terms of welfare, however, is that all income groups enjoy the benefit of a reduced share of their income spent on electricity and gas bills as a result of the energy efficiency improvement. Mid-range income groups (HH 2 and HH 3) are the greatest beneficiaries in this respect (both actually increase the share of income that they are able to save) . The lowest household income group (HH 1) also realises a net welfare benefit in this respect, although it is also the group that reallocates the largest share of its expenditure towards other energy uses, with expenditure on refined oils (primarily petrol and diesel to run cars) rising overall and as a share of total income by just over 12%. Therefore, in terms of welfare, the benefit of energy savings is distributed quite equally across income groups.

Conclusions

Macroeconomic rebound effects appear to be generally welfare-enhancing, with, for example, Lecca et al. (2014) showing that a 5% average increase in household energy efficiency in the UK can increase GDP by 0.1% with a rebound effect of approximately 60%. While the rebound effects are significant, the welfare gains are likely to compensate the energy loss. The results also showed in this case that all income groups benefit from the welfare impacts of energy efficiency improvements, with a greater drop in the real share of income spent on electricity and gas than the drop in energy use.

For policy makers, these results suggest that when, as in this case, the net welfare effects of rebound are positive, the policy should not attempt to remove the rebound effect but rather attempt to maximise the net benefits, while adjusting CO2 emissions emissions forecasts to account for the rebound effects and the reduced CO2 emissions savings that will be achieved through energy efficiency measures. When carrying out a regulatory impact assessment of potential energy efficiency policies, a full welfare analysis should be included and policy decisions based on the multiple benefits of energy efficiency measures, beyond energy and CO2 emissions savings alone.

Footnote

[1] Using a broad-brush energy efficiency increase of 5% as in Lecca et al.

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