International spillover and rebound effects from increased energy efficiency in Germany

This paper would fit in Theme 2, Sub-Theme 2.4, or Theme 3 sub-theme 3.5

Short summary (142 words)

The pollution/energy leakage literature raises the concern that policies implemented in one country, such as a carbon tax or tight energy restrictions, might simply result in the reallocation of energy use to other countries. This paper addresses these concerns in the context of policies to increase energy efficiency, rather than direct action to reduce energy use. Using a global CGE simulation model, we extend the analyses of 'economy-wide' rebound from the national focus of previous studies to incorporate international spill-over effects from trade in goods and services. Our focus is to investigate whether these effects have the potential to increase or reduce the overall (global) rebound of local energy efficiency improvements. In the case we consider, an increased energy efficiency in German production generates changes in comparative advantage that produce negative leakage effects, thereby actually rendering global rebound less than national rebound.

Extended abstract (1170 words)

Overview

There is growing academic and policy debate regarding the need consider how potential direct, indirect and economy-wide rebound effects in energy use may impact the design and implementation of policies to achieve reductions in energy consumption through improvements in energy efficiency. Given the global nature of climate change and international nature of energy supply, this paper proposes that analyses of 'economy-wide' rebound must be extended from the national focus of existing studies. The potential for energy efficiency improvements in one nation to impact energy use in others is important, particularly for policy frameworks such as EU 20-20-20, as it implies that national targets and actions cannot be considered independently. This paper develops a general equilibrium analysis of increased efficiency in productive energy use, identifying a range of channels through which spillover effects may be transmitted as a result of trade in gods and services. We find that energy efficiency in one nation does impact energy use in others but with the sectoral and spatial distribution of positive and negative effects is dependent on the nature of the efficiency improvement and factor supply conditions. Overall, we find that

a shift in comparative advantage in energy intensive production are likely to reduce the magnitude of economy-wide rebound as the boundaries of the economy are expanded.

Methods

The analysis involves examining international spillover effects of a energy efficiency improvement in a production sector in one economy (here, Germany) on total energy use in that and other countries. Therefore, the first step is todefine a global rebound rebound effect, R_g, defining the total impact on energy use in all countries resulting from increased efficiency in the use of energy (E) in sector *i* within the home economy, *d*:

$$R_g = \left[1 + \frac{\dot{E_g}}{\chi\gamma}\right].100 \quad (1)$$

Where γ is the proportionate energy efficiency improvement in sector *i* within the home economy *d*, χ is the initial (base/reference year) share of sector *i* (within country *d*) energy use in total energy use (in both production and consumption in all countries) in the global economy, *g*. Through an adjustment (detailed in the paper) this translates to:

$$R_g = R_d + \frac{\Delta E_{og}}{\gamma E_i}.100 \quad (2)$$

Where the *og* subscript indicates 'other global' (i.e. not including sector *i* or any other production or consumption activity in country *d*). This shows that the total economy-wide global rebound will be greater than the own-country rebound if there is a net increase in external aggregate energy use following the efficiency improvement within country *d*. If there is a net decrease then total global rebound will be lower than own-country rebound. Note that it is possible to identify more than one region within the external global economy and our analysis identifies two external regions: the rest of the EU-27 (member states are modelled separately then aggregated to consider rebound effects) and the rest of the world.

We simulate the impact of changes in energy efficiency (γ) on energy use (E), international spillover effects and economic activity in each regiona more generally using static multi-sector, multi-region interregional computable general equilibrium modelling framework. Details of model specification are given in the full paper but a key feature is that we assume labour and capital stocks to be fixed at the national level but mobile across sectors within each nation. We introduce energy efficiency improvement in the form of a public good. This involves applying a single shock in the form a step increase in energy-

augmenting technological progress at the nest where energy enters the KLEM nested production function and contrasting the resulting new equilibrium to the benchmark situation (without efficiency changes). This approach thus implements a ceteris paribus analysis and allows us to attribute all changes to the efficiency shock. We consider two scenarios. The first scenario is characterised by a permanent step 10% improvement in energy efficiency in the German aggregate manufacturing sectors. The second scenario targets the efficiency improvement at all German production sectors.

Results

Our model suggests that at the global scale rebound effects are significant. 10% energy efficiency improvements in German Manufacturing and in German production overall are associated with global rebound values of 48.11% and 46.58%. That is to say, almost a half of any expected energy saving through improved energy efficiency in production will be taken by rebound effects. However, the results do not show that restricting the focus of the rebound calculation to the economy in which the improvement occurs underestimates the rebound effect: quite the reverse. The rebound values fall in both of the simulation scenarios performed here where the energy use outwith Germany is incorporated in the rebound calculation.

General equilibrium rebound effects for Scenarios 1 (10% increase in energy efficiency in German manufacturing) and Scenario 2 (10% increase in energy efficiency in all German sectors)

	Own-sector R_i	Own-country production R_p	Own-country total R_d	Global EUR_g	Global $World R_g$
Scenario1					
Rebound [%]	56.44	47.63	51.31	50.22	48.11
Change [percentage points]		-8.81	3.68	-1.09	-2.11
Scenario 2	n.a	46.60	50.18	47.28	46.58
Rebound [%]			3.58	-2.90	-0.70
Change [percentage points]					

The logic is straightforward. The standard energy leakage argument concerns policies where firms are encouraged to reduce energy consumption by making energy relatively expensive (through a carbon-tax, regulation or cap and trade policy). However, the rebound phenomenon occurs around policies which encourage the adoption of improvements in energy efficiency and do not directly target energy use or the underlying negative externality (e.g. associated carbon emissions). With such policies, energy, as measured in efficiency units, becomes less expensive so that the relative competitiveness of energy intensive commodities in particular increases. This means that in other countries their production will, in general, become less profitable, and therefore discouraged,. This is reflected in the results obtained in this paper. In the simulations we report, the value of the domestic rebound actually overestimates the global rebound. Of course, we use a general equilibrium system, so that other forces are simultaneously at work. Further, the size and detail of the rebound effects will differ in specific cases.

Conclusions

The key finding of the paper is that macro-level rebound will not necessarily grow as the boundaries of the economy are expanded, and that negative pressure comes from a combination of changes in relative competitiveness, the presence of supply contraints generally and energy supply responses in particular. Thus, in terms of how the research presented here should be developed in the future, supply side issues would seem to be the main priority, through more sophisticated treatment of labour and capital markets, including consideration actor mobility between regions (which would permit consideration of additional potential spillover channels), and treatment of dynamic adjustment of factor supply would allow us to consider the evolution of economy-wide rebound over time. However, given the importance of energy supply responses in the results reported, a priority must be to develop a more sophisticated treatment of energy supply, including consideration of issues such as just how capacity decision are made (which adds emphasis to the need for consideration of dynamic adjustment), the impact of increasing exploitation of renewable energy sources and technologies, and how energy prices are determined in local and international markets.