Supply constraints on rebound effects of increased energy efficiency: negative multiplier and disinvestment effects

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Introduction

Policies that aim to use increased energy efficiency to reduce energy use may not achieve the desired results due to the likelihood of rebound effects. Research from our current ESRC-funded project on this topic was presented in an article in the last issue of Fraser Economic Commentary titled, ‘Energy Efficiency and the rebound effect’ (Turner, 2009a). As explained there, the rebound effect occurs when an energy efficiency improvement causes a decrease in the effective or implicit price of energy as an input to production (or consumption) – i.e. the cost of energy required per unit of activity falls as efficiency improves.[1] Moreover, if there is local production/distribution of energy (or energy services) the reduction in demand for energy as efficiency improves will put downward pressure on the actual (local) energy price.

Such reductions in prices may lead to increased demand for energy throughout the economy that partially or even wholly offsets the anticipated energy savings from the efficiency improvement. Where the increase in energy use is sufficient to entirely offset the initial energy savings, this extreme case of rebound is known as backfire. In the previous article in the Fraser Economic Commentary (Turner, 2009a), we explained that demand responses that drive rebound (or backfire) take the form of substitution, income, output/competitiveness and composition effects, and that the strength of these relative to the pure efficiency effect will determine the magnitude of rebound. Moreover, the strength of these effects will depend on economic conditions in the economy being studied.

However, we also noted that while most of rebound analyses to date have focussed on these demand side responses, our research has highlighted that it is equally important to consider the supply-side response to changing energy demand and local energy prices. In this article, therefore, we summarise findings reported in Turner (2008, 2009b) and Anson and Turner (2009), which consider the local supply response and identify negative multiplier and disinvestment effects as key factors determining the economy-wide outcome of energy efficiency improvements.

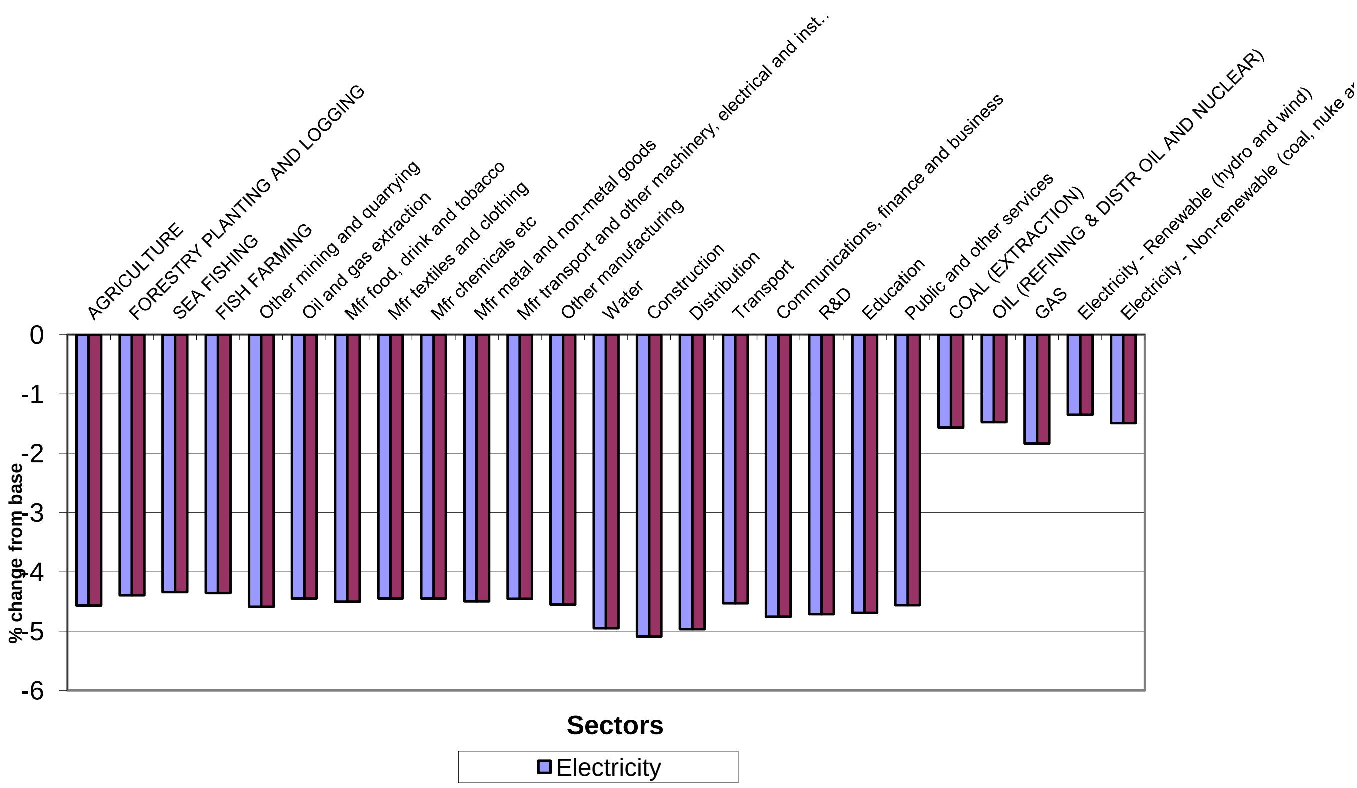
Negative multiplier effects in local energy supply sectors

Multiplier analysis is a familiar term that is commonly used when discussing shocks or disturbances in one area of the economy that have ripple effects throughout the whole economy. For example, by using the Scottish Input Output (IO) tables (e.g. Scottish Government, 2004), published annually by the Scottish Government, interactions and linkages between different production and final consumption sectors can be observed and analysed through simple analytical techniques. Multipliers, as the name suggests, allow us to quantify the magnitude of effect that introducing a change in one area of the economy (usually a change in final demand for the outputs of local production sectors) can have on the wider economic system.

In the context of a change in technology, such as an energy efficiency improvement, there will be a contraction in demand for energy (the pure efficiency effect), which will have knock-on effects throughout the local economy, particularly (or directly) on local energy producers. It is important to note that IO techniques are not ideally suited to modelling the impacts of supply disturbances, such as increased efficiency in the use of energy, particularly because of the lack of consideration of prices (which, as noted above, are the key driver of rebound effects). [2] For this reason the current project employs more sophisticated computable general equilibrium (CGE) modelling techniques. However, the basic IO reasoning, which focuses on backward linkages between sectors, helps us understand what may happen to local energy supply sectors when increased energy efficiency leads to a reduction in demand for their outputs, and how this will feed through and impact on the magnitude of the rebound effect.

Turner (2008, 2009b) investigates negative multiplier effects in Scottish and UK energy supply sectors as a possible

Figure 1: Short run changes in energy use in Scottish production in response to a 5% improvement in efficiency in the non energy supply sectors - limited price responsiveness



Source: Turner (2008)

explanation for the finding of negative rebound effects – i.e. economy-wide energy savings that are greater than those suggested by the initial energy efficiency improvement. [3] This finding runs contrary to the basic idea underlying rebound that any extent of (direct or indirect) responsiveness to changes in the implicit and/or actual price of energy will result in positive rebound effects. However, in an IO analysis, where there is no consideration of price effects whatsoever, and where there is local production and/or distribution of energy, negative multiplier effects in energy supply sectors would be the only impact of an energy efficiency improvement. In order to identify a more realistic scenario, Turner (2008, 2009b) employs CGE analysis to simulate a 5% increase in energy efficiency under conditions where there is very limited price responsiveness in the system to examine whether negative multiplier effects are sufficient to generate negative rebound effects. In order to focus on the multiplier effects in energy supply sectors, the analysis excludes these sectors from the efficiency shock itself. The results for the Scottish case (which are qualitatively similar to those reported for the UK in Turner, 2009b) are shown in Figure 1.

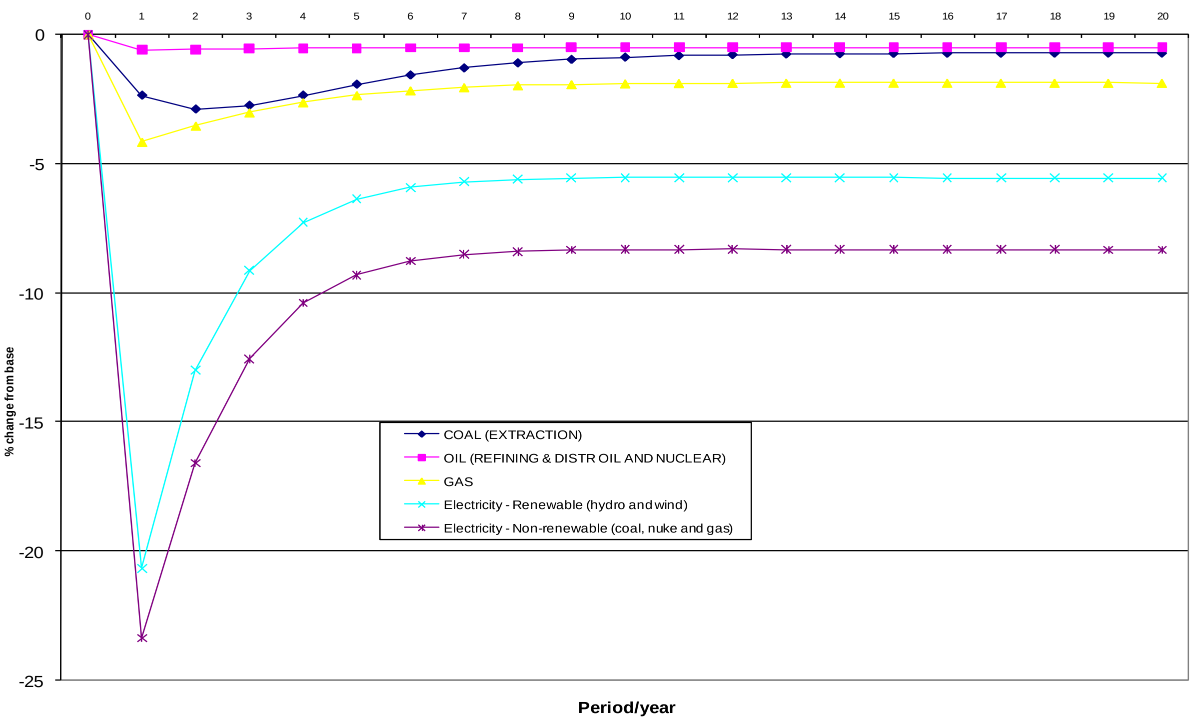
What the results in Figure 1 show is that, even with almost zero price responsiveness, there are positive rebound effects in all (but one) 'energy use' sectors that have been subject to the 5% energy efficiency improvement (i.e. short run reductions in energy consumption are less than 5%). The exception is Construction, but the situation is complicated here by the fact that this sector largely serves investment demand, which, as we will discuss in the next section, are likely to decrease in the area of energy supply when the demand response to falling prices is so restricted.

Instead, the source of the negative rebound effect in this scenario is the reduction in energy use in the energy supply sectors themselves (where there has been no efficiency improvement). This is the result of the direct reduction in demand in the energy use sectors, but also knock-on contractions from the energy supply sectors, where production tends to be very energy intensive.

Disinvestment effects in local energy supply sectors

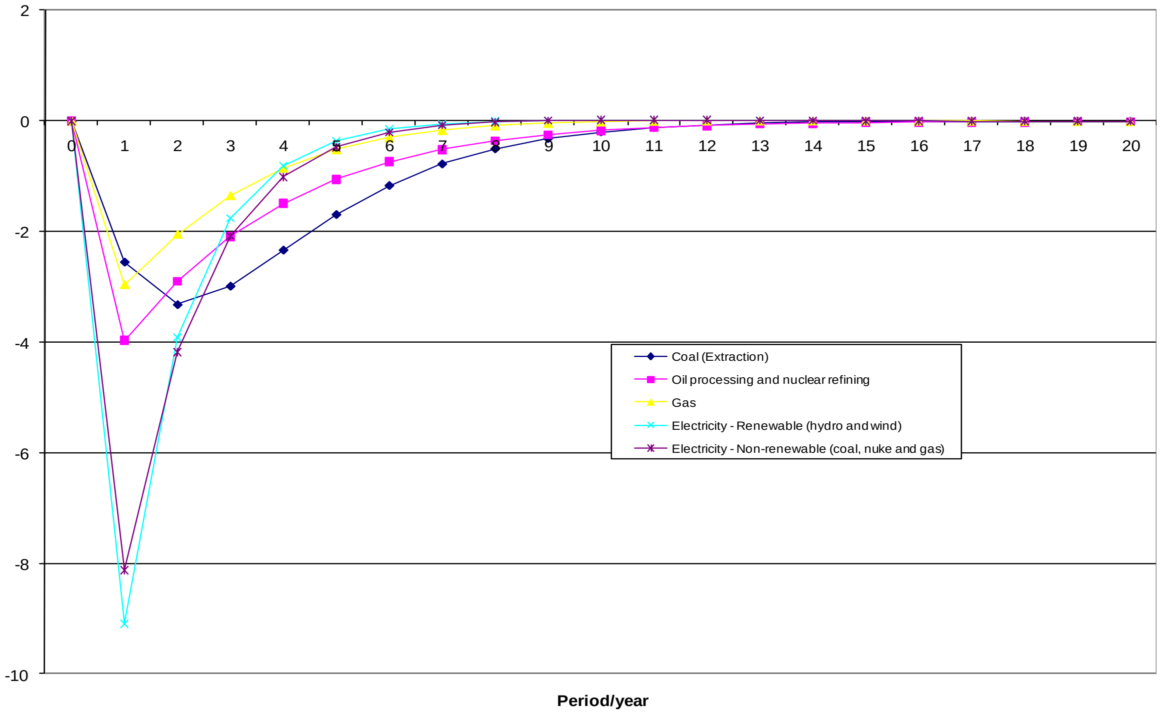
The negative multiplier effects observed in Figure 1 may carry through to the longer run. However, after the initial reduction in demand from the pure efficiency effect, it is the impact on implicit and/or actual energy prices that drive the substitution, income, competitiveness and composition effects (discussed in the previous article - Turner, 2009a)

Figure 2: Percentage change in UK local energy supply prices in response to a 5% improvement in energy efficiency in all production sectors (applied to locally supplied energy)



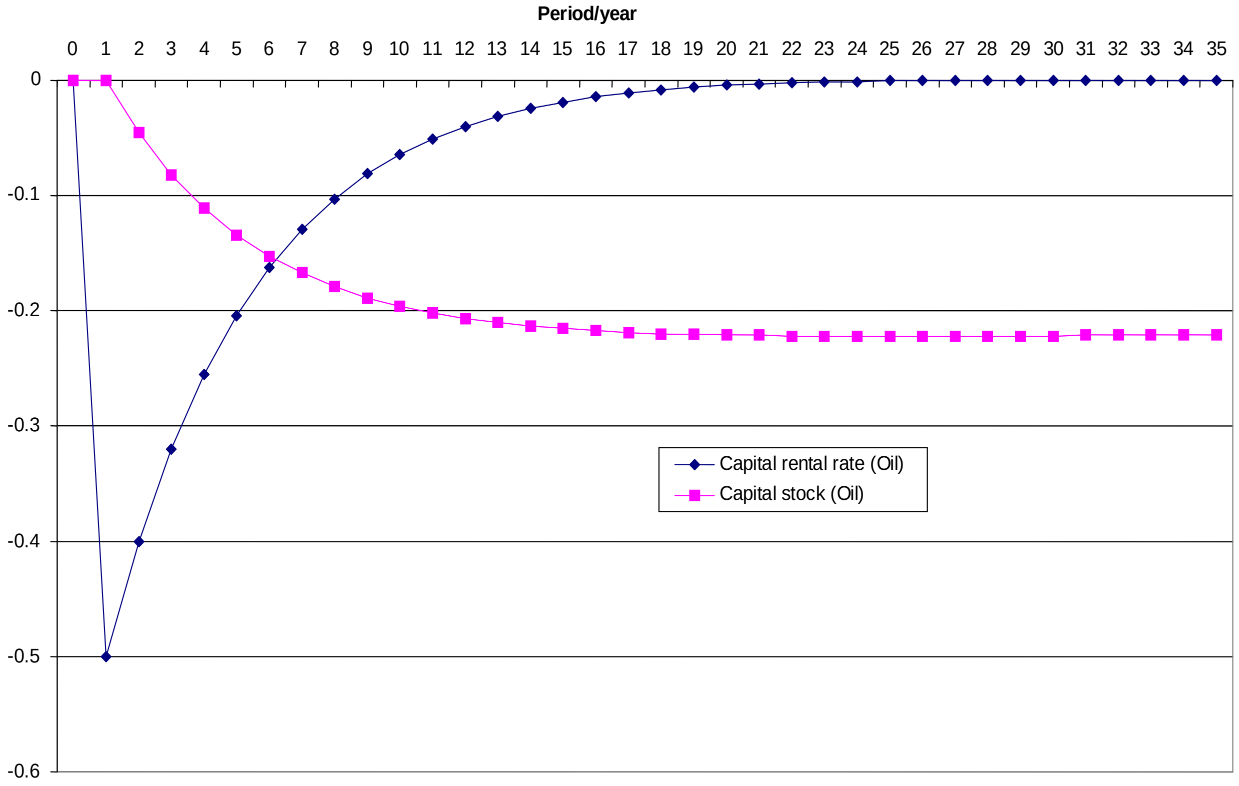
Source: Turner (2009b)

Figure 3: Impact on capital rental rates in the UK energy supply sectors of a 5% increase in energy efficiency in all production sectors (% change from base)



Source: Turner (2009b)

Figure 4: Impact of a 5% energy efficiency improvement in the Scottish Transport sector on capital rental rates and capital stocks in the Scottish Oil supply sector (% change from base)



Source: Anson and Turner (2009)

that drive rebound. As noted above, these are all demand responses to changing prices. However, Turner (2009b) and Anson and Turner (2009) demonstrate that it is also important to consider the supply response to changing prices, particularly in the case of local energy supply sectors.

The key point to understand is that when the price of a commodity or service falls, if there is not a sufficient demand response then revenues and, in turn, the profitability of the sector that produces these as output will fall, leading investors to relocate their capital where the return is greater. In the context of a decrease in local (actual) energy prices triggered by an efficiency improvement, this will occur in the case of the local energy supply sectors. Turner (2008, 2009b) refers to this process as the 'disinvestment effect'. Unlike negative multiplier effects that dampen rebound immediately after an energy efficiency improvement, the disinvestment effect takes hold as we move into the longer term. However, it is triggered by the (negative) impact on local energy supply prices and capital rental rates immediately after the shock is introduced.

Figure 2 shows the impact of a 5% increase in energy efficiency all production sectors on local energy supply prices of the UK economy from Turner's (2009b) UK CGE
analysis. Note that there is a substantial decrease in the actual price of output in the (both renewable and non-renewable) electricity supply sectors. Particularly due to the lack of trade in electricity between the UK and rest of the world (i.e. there is very limited external demand response to these decreased prices), the demand response to this drop in prices is insufficient to prevent a drop in revenue in these sectors. In turn, this reduces the return on capital, as shown in Figure 3. This leads to shedding of capital stock (and capacity) in these energy supply sectors. This tightening of energy supply causes local energy prices to rise, which allows the return on capital in these sectors to adjust back to their initial real levels (and equate with the user cost of capital, so that equilibrium can be restored in the economy). This process is illustrated in Figure 2. It is this 'rebound' in local energy prices that leads to the dampening of the long-run rebound in energy use in the UK case modelled by Turner (2009b).

Turner (2009b) finds that disinvestment effects do constrain the rebound effect in the UK under most assumed simulation scenarios (which relate to differing degrees of price responsiveness in the system). However, Turner (2008) shows that, given the different structure of the Scottish economy, and particularly the extent of trade of energy supply sector outputs, this is generally a less common outcome in the case of Scotland.
Generally, Turner's (2008, 2009b) results show that the influence of the disinvestment effect is reduced the more price responsiveness we bring into the system (the next question then, is correctly specifying direct and indirect price responsiveness throughout the system – this is the focus of current research, as noted in the conclusion section).

However, the analyses reported so far are fairly broadbrush in so much as all sectors of the economy are targeted with the same efficiency shock. We have also carried out research at the sectoral level, first in a report to Scottish Government (Allan et al 2008), but later, and with more detailed analysis in Anson and Turner (2009). Here, the (5%) energy efficiency improvement is targeted specifically (and solely) at the Scottish commercial transport sector. Here, even with a fairly flexible degree of price responsiveness on the demand side of the economy, we do observe disinvestment in the Scottish refined oil supply sector (hereafter simply the 'Oil' sector), the major energy supplier to the transport sector. Figure 4 shows the impact on the return in capital in the 'Oil' supply sector and the consequent contraction in capital stock.

The presence of disinvestment in the Scottish 'Oil' supply sector as a result of changes to the Scottish commercial transport sector is illustrative of our argument that rebound and disinvestment effects are specific to the economic structure under observation and the sectors targeted with the efficiency improvement. In fact all our research in this area has shown is that the key drivers of rebound (and also the disinvestment effect) are sensitive to the flexibility and degree of price responsiveness in the economic system being studied.

Conclusions

The two key result of our rebound research to date are that (1) there is positive pressure for rebound effects even where (direct and indirect) demands for energy have a low price responsiveness, but (2) this may be partially or wholly offset by negative multiplier and disinvestment effects that occur in response to falling energy demand and prices respectively. While the empirical analyses presented here are specific to the case studies of Scotland and the UK, we believe that the observation and explanation of negative multiplier and disinvestment effects that act to dampen rebound effects provide a more generic insight. Both will have more general significance in analysis of energy efficiency improvements in other economies where there is domestic supply of energy. Turner (2009b) also argues that the disinvestment effect in particular may be applicable at the global level where, despite OPEC's command of marginal supply, downward demand pressures do exert downward pressure on prices.

Our results also show that the disinvestment effect is a necessary, but not sufficient, condition for rebound effects to be bigger in the short run than in the long run (as short run rebound may also be dampened by negative competitiveness effects), a result that runs counter to the theoretical predictions of Wei (2007) and Saunders (2008). We should note that Wei (2009) has also begun to focus his theoretical analysis on supply side issues, partly in response to Turner (2009b), but considering the supply response to increased energy efficiency more generally (e.g. resource scarcity will also be an important issue in analyses with a wider geographical focus).

In future research we hope to extend our analysis to an interregional framework in order to examine (a) spillover rebound effects (i.e. how energy efficiency increases in one economy may affect energy use in others, and (b) potential negative multiplier and disinvestment effects in energy supply sectors in regions/countries that energy is imported from (e.g. in our Scottish simulations, the supply and price of energy imported from the rest of the UK is exogenous). We attempt an interregional analysis of increased labour efficiency in Turner and Hanley (2009). This work extends on our single region analyses comparing the impacts of increased energy and labour efficiency on the CO2 intensity of GDP in Turner et al (2009).

Finally, we remind the reader that the results summarised here are sensitive to be sensitive to elements of model specification. In particular, further research is ongoing to attempt to accurately quantify some of the key parameters that govern the magnitude of rebound effects, and the occurrence of disinvestment effects.

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Endnotes

[1]The rebound argument holds when there is a change of efficiency to any factor of production and not just an energy input. As part of this research project we have also looked at changes to labour efficiency in the UK and Scottish economies. Links to all project outputs to date such papers can be found at http://www.esrcsocietytoday.ac.uk/esrcinfocentre/viewawardpage.aspx?awardnumber=RES-061-25-0010.

[2]This is also a problem in modelling the impacts of changes in demand.

[3]Saunders (2008) discusses the possibility of 'super conservation' effects where energy savings are proportionately greater than the initial increase in energy efficiency. However, Turner's (2008, 2009b) CGE