Energy Efficiency Saving, Rebound Effects and the Impact of Energy Policy Instruments: Evidence from EU Countries

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Overview

Over the past two decades, energy efficiency improvement has become a vital energy policy objective towards attaining energy conservation and reducing greenhouse emissions. The importance of efficiency improvement in practical policy settings derives from the notion/assumption that efficiency gains will reduce energy consumption and the attendant greenhouse emissions by proportionate magnitudes, in a non-disruptive manner. However, a strand of the energy economics literature provides empirical evidence that the existence of ex-post rebound effects may reduce (or even erode) the energy savings resulting from improved energy efficiency (see Chakravarty *et al*., 2013). From an economic point of view, energy efficiency reduces the effective price of energy i.e. energy services become cheaper, even if physical energy prices are unchanged. For instance an energy efficient car reduces the cost of driving per mile, even when the pump price of petrol remains constant. The lower cost of driving then induces greater driving, resulting in more energy use- the rebound effect. This implies that the global climate agenda of reducing energy consumption in the face of lower effective energy prices (resulting from efficiency gains) and high economic growth is extremely difficult with (Birol and Keppler, 2000). Hence, the presence of rebound effect behaviour within energy systems poses significant risks to the effectiveness of energy efficiency policies. Consequently, it can argued that, in addition to improving energy efficiency, countries should also aim to reduce or minimize rebound effects in order to 'lock-in' energy efficiency savings. It is important to quantitatively assess/benchmark countries with the minimum rebound effect. Further, it is also crucial to reliably evaluate the role of policy instruments in mitigating rebound in order to guide policy makers in effectively tackling this challenge.

Methods

The benchmarking exercise has been performed using the parametric stochastic frontier analysis (SFA) which was introduced by Aigner et al. (1977) and Meeusen and van den Broeck (1977). The SFA allows for a composed error term which contains a one-sided error term to measure relative 'slack' or deviation from the minimum rebound frontier, and the traditional two-sided error term which captures random noise. The objective is to construct a best-practice rebound effects stochastic frontier to unravel the degree to which a country could potentially reduce its rebound effect, relative to the other countries. To achieve this, an input distance production function approach is employed where EU countries' production technology is modelled to produce national output, choosing the input-minimizing combination of capital, labour, energy and rebound effect. In addition, the impact magnitude of two energy policy instruments on the frontier is also estimated in order to explore the effectiveness of the policies. The energy policy instruments are energy taxes and energy R&D investments and they are incorporated in our model using two specifications namely the panel data model proposed by Battese and Coelli (1995) (Model 1) and alternative specification proposed by Reifschneider and Stevenson (1991), Caudill and Ford (1993) and Caudill et al. (1995) (Model 2). Finally, we estimate and decompose the total factor productivity (TFP) of the EU countries into the component parts: technical change (TC), efficiency change (EC) and scale change (SC).

Results

Our modelling results found considerable variation across sampled EU countries in terms of performance in managing or minimizing rebound. Both estimated models show generally steady improvement (5-10%) in average rebound performance over the sample period, possibly indicating an encouraging sign of EU countries, indicative of the progress that EU countries have made in "locking-in" energy efficiency gains. Furthermore, we find interesting results on the role of enrgy policy instruments in this performance. For both models, energy taxes are shown to have a statistically significant negative (reducing) impact on rebound effects. This is not surprising, given that energy taxes appear to better internalize or capture the negative externalities arising from energy use. However, for the energy R&D, this is found to have either a positive or statistically insignificant effect on rebound effects, implying little or no impact on rebound effects over the sample period. In general, the overall implication of the estimated policy effects is that binding market-based instruments such as energy taxes have been more effective in tackling rebound effects, compared to indirect instrument such as R&D expenses or subsidies. Finally, both models indicate that Denmark and Ireland are the most successful countries in mitigating rebound effects, while Czech Republic and Slovakia appear to have been relatively less successful in tackling this problem.

Conclusions

By benchmarking rebound effects, it is possible to evaluate EU countries' performance and progress in terms of mitigating/minimizing rebound effects. This is important because, in the presence of rebound effect, using only energy efficiency performance as a benchmark may provide incomplete and misleading information in policy settings. Therefore, unless a rebound effects frontier is estimated , it may be impossible to actually evaluate relative progress of energy efficiency policies. Intutively, a country with a high level of energy efficiency, but also high rebound magnitude should be designing allied policies to secure or 'lock-in' such efficiency gains by mitigating rebound effects.

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