QUANTIFYING CONSUMER REBOUND EFFECTS USING A MODEL OF ENERGY SERVICE DEMAND.

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Overview

In recent years the rebound effect has been at the forefront of discussion in the economics of energy. The empirical magnitude of the rebound effect has been widely contested, studies have suggested that energy efficiency improvements can lead to rebound of about 30%, but with some suggesting figures over 100%. This has generated a lot of attention and even concern amongst environmental and energy economists. A key variable in identifying the rebound effect is the efficiency of an energy service. However, this underlying efficiency is not observable. Some existing papers for instance use fundamental engineering relationships along within a Becker type household consumption framework to indirectly quantify rebound effects from models of service demand. Though, the assumptions in such models are not always convincing, and which are no always supported under testing.

The aim of this paper is therefore to build on an alternative energy service demand framework. Importantly the role of unobservable energy efficiency is explicitly incorporated into the economic and subsequent econometric model. This leads to methodological concerns relating the identification of the latent efficiency process as well as the estimated parameters of the demand function e.g. the price elasticity of demand. Unobserved components statistical methods are used to overcome these.

Methods

A generalized service demand model is derived leading to the following linearized almost ideal demand system (LAIDS):

$$s_{ti} = \alpha_i + \sum_j \gamma_{ij} \ln(p_{ij}) + \beta_i[\ln(B_t) - \ln(P_t)] + \varepsilon_{ti}$$

s_{ti} is the budget share of the *i*'th energy source, α_i, γ_{ij} and β_i are parameters to be estimated, *B* is some measure of income, *P* a general price index, *p* the price of the *j*'th energy source, and ε_{ti} is an unobservable energy efficiency term. subscript *t* denotes the time period. The usual behavioral constraints are applied such that $\sum \alpha_i$ = 1, $\sum \gamma_{ij}$ =0, $\sum \beta_i$ = 0 and γ_{ij} = γ_{ji} . Additionally for the efficiency term ε_{ti} it is required that $\sum \varepsilon_{ti}$ = 0 for all *t*.

Given the derived model, in addition to the standard price and income elasticities, an `overall' rebound effect can be derived. This effect has some nice features in that it quantities rebound behavior from the consumer perspective within a much more robust microeconomic framework than some previous related studies.

Estimation of the model introduces some difficulties since the efficiency term is unobservable. Harvey and Marshall (1991) overcome a similar problem (in the context of a Translog production function) using state-space methods to model technology effects as unobserved components. More recently Broadstock and Chen (2013) applied the same method within a LAIDS model. The estimation procedure utilize the time dimension of the data to statistically identify the unobserved term using a Kalman filter/smoother and maximum likelihood.

The theory component of the work is closely based on recent work by Lester Hunt and David Ryan (2011).

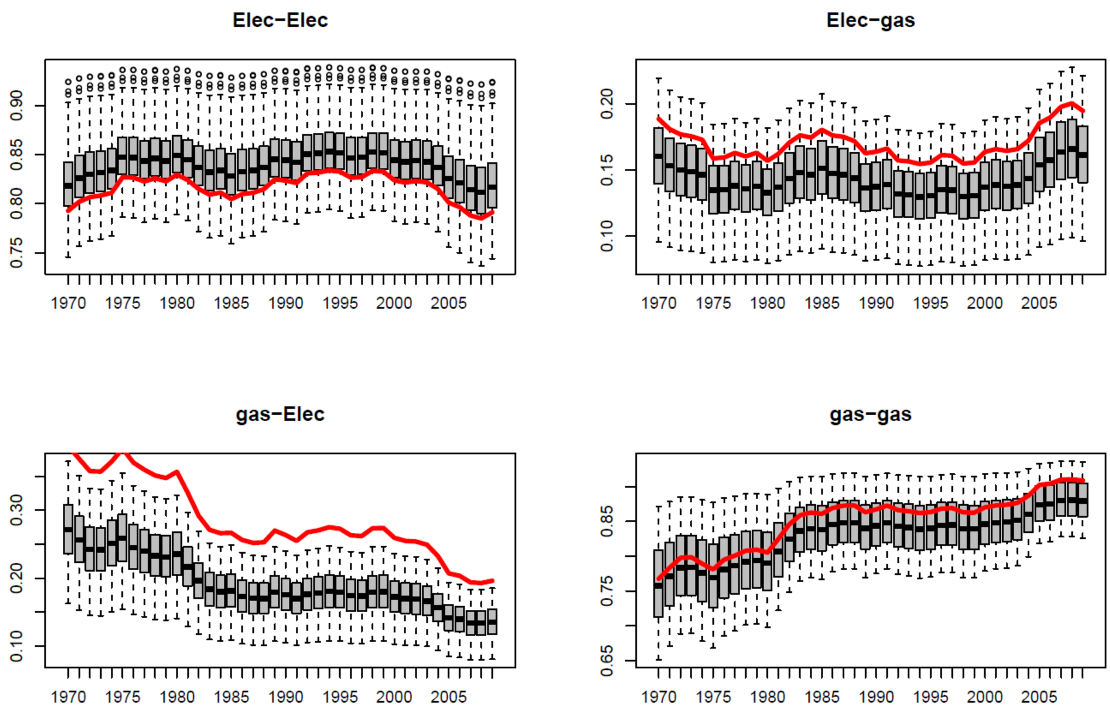
Results

The model is illustrated using a sample of data for UK energy consumption/expenditure, measured annually from 1964-2009. The energy sources included are electricity, gas and `other' sources, e.g. oils and solids. Income and price deators are taken from the Office of National Statistics online database.

The results suggest that the rebound effect is of approximately the same order of magnitude as the price elasticity, at around 0.8 and therefore towards the higher end of estimates discussed in the literature. The state space model estimates are further compared with standard LAIDS parametric estimates with deterministic time trends, and importantly policy assertions can be made. Using the standard approach (quadratic) technology seems insufficiently exible to capture the latent dynamics of the unobserved energy efficiency, with the consequence of transferring some `bias' to the from the income elasticity and efficiency estimates on to the price elasticity. Whilst the direction of transfer is specific to the data used, the concept of bias is likely to be much more general.

Conclusions

The results reveal that the nature of the energy market in the UK, and the way that the aggregate consumer perceives energy has changed a lot between 1970-2009. With gas having shifted status from being a complement to overall consumption in 1970, to a substitute in 2009. Other elasticities and rebound effects vary dramatically across time also. The direct rebound effects are much more severe than the indirect rebound effects, suggesting that policy design might favor tackling these first, but there is probably an argument that energy prices are able to `manage' the rebound effects quite effectively, and if self-regulated market prices do not suitably mitigate direct rebound, modifying energy taxes is a cheap and obvious solution. Perhaps more relevant is the fact that the indirect rebound effects are (i) not insubstantial given the negative externalities associated with them and (ii) not at all easy to manage with simple policy instruments. Future related research might then benefit from trying to better understand the specific mechanisms by which indirect rebound effects manifest.



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