Varying Price Elasticities of Energy Carrier Specific Demand in the Residential Sector

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Overview

With the most recent development on the energy markets caused by the Russian war against Ukraine and increasing efforts to address climate change particularly in the European Union, effects of rising energy prices on consumption and consumer reactions to energy prices are the center of interest particularly in the political debate. In this regard, knowing and understanding price elasticities of energy demand is important for two main reasons:

Firstly, in light of increasing energy prices due to the Russian war in Ukraine many countries implemented support programs and relief measures. In order to determine the appropriate scope of relief measures policy makers have to know how price elastic energy demand is. Secondly, climate change mitigation is increasingly gaining in importance in EU policy which is shown by the Green Deal which sees to make Europe carbon neutral by 2050. In order to achieve this goal, member states of the European Union increasingly make use of carbon taxation or other price policies and recent studies conducted by Runst / Thonipara 2020 or Shmelev Speck 2018 point towards carbon taxation being particularly effective if set on a high enough level as it is the case in Sweden. With carbon taxation becoming a more and more used policy instrument to reduce carbon emissions in the residential sector insights are necessary on how different levels of pricing or taxation may affect energy demand. The residential sector plays in this regard an important role since residential buildings account for around 25% of the European Union’s energy use according to Eurostat. The residential sector is also focus of relief measures due to increasing energy prices.

So far studies on price elasticities of energy demand in the residential sector are limited. Besides, the limitation of these studies is, that price elasticities were calculated using total energy use or total energy use for space heating use as the dependent variable. This means that the use of different energy carriers such as coal, district heating, biomass, oil or electricity is aggregated. Using aggregated demand as a dependent variable brings along two main disadvantages. Higher prices due to the carbon tax would usually lead to decreasing demand of the respective energy carrier. Demand of energy carriers poor in emissions would on the other hand increase since their prices are not as strongly affected by the carbon tax. The aggregated demand, however, does not picture this inter-fuel substitutional effect. Equally, energy prices usually vary across different energy carriers but are put into one price and are treated as if they were equal.

Thus, the aim of this research is to assess comprehensively the varying price elasticities (price and taxes) of the different energy carriers and to explore patterns of substitutions. A further focus of this paper are differences in price elasticities between one and two family houses and multi-dwelling houses. Energy efficiency has become an integral part of the EU environmental policy as a means of addressing climate change. The residential sector plays in this regard an important role since residential buildings account for around 25% of the European Union’s energy use according to Eurostat. Thus, the Green Deal sees to make Europe carbon neutral by 2050. In order to achieve this goal, member states of the European Union increasingly make use of carbon taxation or other price policies and recent studies conducted by Runst / Thonipara 2020 or Shmelev Speck 2018 point towards carbon taxation being particularly effective if set on a high enough level as it is the case in Sweden. With carbon taxation becoming a more and more used policy instrument to reduce carbon emissions in the residential sector insights are necessary on how different levels of pricing or taxation may affect energy demand.

Methods

As a first step, I use a standard dynamic constant elasticity function of demand in order to capture short and long run price elasticities. The analysis is limited to the time period from 1990-2016 and to a number of European countries both due to data availability. ***The*** dependent variables (consumption of the respective energy carrier α = gas or oil or electricity) includes water heating, space heating (and cooling) as well as appliance use. As net energy prices are likely to be affected by energy demand, we use an instrumental variable approach in order to rule out endogeneity caused by reverse causality. Besides net prices of the respective energy carrier α *I* use the energy carrier specific tax per ton of oil equivalent in order to capture the effect of energy taxes on energy consumption. As I use logarithms I can interpret the coefficients as the price elasticities as long as a lag of the dependent variable is included as well as a number of explanatory variables. The explanatory variables include Heat Degree Days (HDD) in order to control for year specific weather effects, population as more people use more energy as well as GDP per capita since *I* expect that with higher income energy use increases due to lower energy price intensities as well as more appliances used as well as larger homes. Furthermore the other energy carriers' (μ) end user prices are included in the model.

For each model I use a second specification which includes an interaction term of energy taxes and per capita income (IntTI) in order to capture the effect that an energy tax increase may be more important if energy expenditure takes up a large part of a household's budget. Finally, hetereoskedasticity and autocorrelation robust standard errors are specified.

First specification

$$Consumption(\alpha)_{it} = \beta_0 + \beta_1 log(\widehat{netprices}(\alpha))_{it} + \beta_2 \log(tax(\alpha))_{it} + \beta_3 HDD_{it} + \beta_4 population_{it} + \beta_5 GDPpC_{it} + \beta_6 energy\ prices\ (\mu)_{it} + \varepsilon_{it}$$

Where:

$$\widehat{netprices}(\alpha)_{it} = \gamma_0 + \gamma_1 (\log(netprices(\alpha))_{it-1} + \gamma_2 exogenous\ regressors_{i(t)} + \varepsilon_{it}$$

Where:

$$\gamma_2 = 0$$

Second Specification

$$Consumption(\alpha)_{it} = \beta_0 + \beta_1 log(\widehat{netprices}(\alpha))_{it} + \beta_2 \log(tax(\alpha))_{it} + \beta_3 HDD_{it} + \beta_4 population_{it} + \beta_5 GDPpC_{it} + \beta_6 energy\ prices\ (\mu)_{it} + \beta_7 IntTI_{it} + \varepsilon_{it}$$

However, as more recent literature on price elasticities use cointegration techniques in order to calculate price elasticities I also use an Autoregressive Distributed Lag Model in order to calculate long run price elasticities and an error correction model to calculate short run price elasticities.

$$\Delta logConsumption_{\alpha_{it}} = \vartheta_i [y_{it-1} - \lambda'\ X_{it}] + \sum_{j=1}^{p-1} \gamma_{ij}\ \Delta logconsumption_{it-j} + \sum_{j=0}^{q-1} \gamma'_{ij}\ \Delta log\bar{X}_{it-j} + \varepsilon_{it}$$

$\vartheta_i [y_{it-1} - \lambda'_i X_{it}]$: error correction term

λ' = vector of long-run relationships

γ' = short- run dynamic coefficients

j = lags – optimal number of lags are used

In both models I use further explanatory variables including GDP per capita, average floor area and heating degree days.

Results

First results show that price elasticites vary vastly if you have a more detailed look at different subsamples.

- Price elasticities of oil demand is higher than those of gas demand, whereas electricity demand has very low price elasticities probably due to a lack of substation possibilities
- Price elasticites of energy carrier specific demand are drastically higher in countries that have experienced strong price increases (such as driven by carbon tax increases)
- Short run price elasticities in one family houses are significantly higher compared to multi-dwelling buildings which suggest that one family houses can respond faster to price changes by either consuming less energy or investing in more efficient technologies or changing the form of heating

Conclusions

The first results show that price elasticities of energy demand vary vastly depending on the energy carriers, the building types, ownership as well as depending on the occurrence of sharp price / tax increases. These first results provide valuable evidence for the elasticities and responsiveness of different parts of the residential sector's energy consumers on rising prices which is particularly interesting for determining a size of a carbon or / energy taxation in order to reach climate goals or for predicting residents' behaviour when deciding upon relief measures as response to the currently sharply increasing energy prices.