MODELLING RESIDENTIAL ELECTRICITY DEMAND IN EUROPE WITH AUTOMETRICS™.

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(1) Overview

The European Union is committed to delivering affordable, secure and sustainable energy supplies to households and businesses, as this is expected to improve people's well-being and industrial competitiveness. In 2007, the European Council set out important energy policy goals for 2020: to reduce greenhouse gas emissions at least by 20% compared to the level of 1990, to increase the share of renewable energy in EU energy consumption to 20%, and to make a 20% improvement in energy efficiency. To reach these targets, EU policy makers can effectively work on the demand side of the electricity market, promoting energy conservation measures that employ tools like environmental tax, mandatory energy efficiency standards for new appliances and incentive schemes for substituting old electrical equipment.
An accurate model of electricity demand that provides reliable estimates of long-run elasticities, is therefore crucial for the EU energy policy decision makers. In particular, a great deal of attention should be paid to the modelling of residential electricity demand, given that over the last twenty years, in the EU-27 area, this sector has accounted for about the 29% of total final electricity consumption .
This paper estimates residential electricity demand for nine European countries, namely Austria, Belgium, France, Germany, Italy, Spain, Switzerland, the Netherlands and the UK, using annual data for the period 1978-2009. These countries have amongst Europe's largest residential sectors, contributing in 2009 for about the 75% of residential electricity consumption of the area comprising EU-27 and Switzerland (839 TWh).

(2) Methods

Over the past two decades, several studies have applied different econometric techniques to model energy/electricity demand, in particular cointegration analysis and structural time-series models, to define a stable relationship between residential electricity demand and its determinants. In the vast majority of the literature, the variables used to explain electricity demand have been household income, electricity price, substitute goods' prices and temperature. Only a few scholars have accounted for the impact of endogenous irreversible improvements in technical efficiency on electricity consumption as well as other exogenous factors such as exogenous technical progress (brought about by changes in regulation and standards that impact energy efficiency), changes in consumers' preferences and changes in the socio-economic structure of a country (inter alia Amarawickrama and Hunt, 2008; Dilaver and Hunt, 2011a, b). Neglecting these variables could result in inconsistent estimates of price and income elasticities, see for instance Haas and Schipper (1998), Griffin and Schulman (2005), Dilaver and Hunt (2011a, b). In particular, omitting such factors in the estimation of a long-run relationship between energy demand and its determinants would lead to an incorrect rejection of a meaningful cointegration relationship. Moreover, even in the case where a long-run relationship is found, most likely the cointegrating relationship will be unstable. However, given the difficulty of measuring endogenous technical change and other exogenous factors, there is no consensus in the literature as to how to incorporate these variables when estimating energy/electricity demand.
The methodological contribution is to specify a cointegrating relationship between electricity demand, gross domestic product (GDP), electricity price and potential instability factors, such as energy-saving technical change, changes in consumers' tastes and in the socio-economic structure. The general unrestricted error correction mechanism (ECM) is employed to identify a cointegrating relationship, while the instability factors are modelled using the Impulse Indicator Saturation framework (Hendry, 1999) and its related extensions (Ericsson, 2011), which provide a procedure for analysing parameters' constancy, testing for unknown breaks occurring at unknown times. Model estimation is performed with the tool Autometrics™, included in the econometric package OxMetrics6.2 (see Doornik, 2009). Autometrics™ is a search algorithm that performs automatic general-to-specific model selection when there are more regressors than observations.

(3) Results

The results of estimation highlight that cointegration between electricity demand, GDP and electricity price is present for all nine the European countries considered. Structural breaks, denoting also omitted variables, are found for all the cointegrating relationships and are correctly taken into account, as the models pass the misspecification tests (including the AR 1-2 test of Breusch and Godfrey, the ARCH 1-1 test of Engle, the Normality test of Jarque and Bera, the Hetero test of Breusch and Pagan and the RESET23 of Ramsey). Moreover, all the income and price elasticities, but income elasticity of Belgium, are statistically significant and have the correct sign, i.e. positive for income elasticity and negative for price elasticity. Income elasticities are less than one or close to one for all countries, which is in line with that electricity is a necessity good rather than a luxury good for developed nations. Residential electricity demand is price inelastic, as price elasticities are always less than one in absolute value. Both elasticities are in line with previous literature, with income elasticities ranging between 0.20 (UK) and 1.29 (Netherlands), and price elasticities ranging between -0.45 (Switzerland) and -0.03 (Italy).

(4) Conclusions

This paper estimated the determinants of residential electricity demand for Austria, Belgium, France, Germany, Italy, Spain, Switzerland, the Netherlands and the UK, using a novel econometric approach that allows modelling structural breaks in the cointegrating relationship between electricity demand and its determinants. The selected countries represent Europe's largest economies and account for the majority of European electricity consumption. Modelling structural breaks allows to capture a series of factors that are difficult to measure (i.e. technical progress, changes in consumers' preferences and in socio-economic structure), but if neglected could lead to inconsistent estimates of price and income elasticities. The methodology implemented in this study consisted in employing the general unrestricted ECM with structural breaks to model the cointegrating relationship between electricity demand, GDP and electricity price, where the instability factors were modelled using the Impulse Indicator Saturation framework (Hendry, 1999) and its related extensions (Ericsson, 2011). The estimation of the residential demand models was carried out with the search algorithm Autometrics^{TM}, which allows performing general-to-specific model selection when there are more regressors than observations.

The results found in this study have important implications for EU energy policy makers, given that the countries analysed make up the 75% of the final consumption of the EU-27's residential sector. In particular, the finding that price elasticity is very low for all countries implies that any policy aimed at energy conservation only via price increase would have a small effect on reducing consumption, while causing a heavy loss in consumer welfare. Hence, to meet the long-term goals of decarbonisation, the EU policy makers should continue with energy policies that feature higher efficiency standards for new appliances; installation of smart meters that allows monitoring the household's consumption in real time; monetary incentives, such as grants and tax credits, to upgrade or replace old equipment. Moreover, European households should be strongly incentivised to adopt a local model of production and consumption of electricity, such as that achievable with installation of solar panels, small-scale wind turbines and low-carbon micro heat and power plants.

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