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Electricity prices and energy intensity in Europe

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ABSTRACT

The purpose of this article is to analyse the impact of residential electricity prices on energy intensity in Europe. The research is primarily based on a panel analysis for the European Union (EU-28) member states plus Norway over the period 1990–2015, to which a fixed-effect estimator was applied. The results suggest that the residential electricity price has one-third on energy intensity, taking into account the control variables. This implies that the level and structure of electricity prices should be considered as a potential energy policy tool for improving energy efficiency by reducing energy intensity. The results also suggest that energy intensity in Europe was favourably affected by the restructuring of industrial companies in transitional economies, the implementation of national programmes for improvement of energy efficiency, and the introduction of EU Emissions Trading Scheme.

1. Introduction

Sustainable development is monitored by the European Union (EU) using different sustainability indicators, energy intensity (EI) being among the most important ones (Grzebyk and Stec, 2015). Many researchers have analysed EI as one of the drivers of economic development and energy consumption (Freeman et al., 1997; Streimikiene, 2007; Ahmed and Azam, 2016; Sweidan and Alwaked, 2016; Zhang et al., 2016; Lan-Yue et al., 2017). Energy intensity is defined in terms of the energy required from coal, electricity, oil, natural gas, and renewable sources per unit of output as typically measured by gross domestic product (GDP). As the ratio of gross inland consumption and GDP, energy intensity is represented in kilograms of oil equivalent (kgoe) per EUR 1000. If an economy uses less energy per unit of GDP, it is considered more energy efficient. In practice, however, this relationship is more complex, as energy intensity is affected, among other factors, by the structure of an economy, structural changes, technological development, climate, and many other factors (IEA, 2009).

The aim of the EU is to achieve 30% savings in primary energy consumption by 2030 (EC, 2016a,b). Enhancing energy efficiency in the residential sector was of special interest, as it presents substantial potential for cost-effective savings (Cerin et al., 2014). In the structure of end-use energy consumption, households have a 24.8% share, which has increased steadily by a total of 25% since 1990 (EC, 2016a,b). Residential electricity consumption is especially high for building heating and cooling of space and water, as well as for cooking. Electricity consumption for heating is especially high in Norway, Finland, Estonia, and the Czech Republic, with shares of about 60%. However, since 2000, there has been some improvement in most countries. Sweden, the Netherlands, and Germany reduced electricity consumption due to energy efficiency improvements, while Romania, Slovenia, Latvia, and Slovakia experienced behavioural savings linked to higher prices and lower income (EC, 2015).

The impact of residential energy policies can be observed as a reduction in energy usage in the construction industry, improved technological performance, reasonable energy consumption, and switching to renewable sources (Andrews-Speed, 2009; Haas et al., 1998; Weiss et al., 2012; Howard et al., 2006; Boardman, 2004). However, lack of information, along with technical, institutional, legal, and financial barriers, have been identified as market failures and obstacles to investment in energy efficiency. It has been found that market-based and organizational/individual behavioural factors play important roles in energy efficiency investment towards sustainable development (Lee, 2015). The crucial factors for enhancing energy efficiency can be summarised as incentives, information, initiatives, innovations, and investment (Golubchikov and Deda, 2012). The results of empirical research imply that

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financial incentives and energy performance standards have improved energy efficiency, whereas labelling and educational campaigns as informative methods have not had a significant effect on fostering efficiency (Filippini et al., 2014).

Several structural aspects should be taken into account. Liberalisation policies and competitive markets, for example, are expected to result in enhanced economic efficiency and lower electricity costs and prices. Several authors empirically demonstrated that efficiency increases and electricity cost decreases due to regulatory reforms (Akkemik and Oguz, 2011; Kunneke and Voogt, 1997). On the other hand, experiences from Slovenia (Hrovatin et al., 2009) and South East European countries (Pollitt, 2009) showed that in most cases, electricity price increases. Most of the recent research demonstrates that regulatory reforms and the subsequent increase in electricity price are two main factors that can improve energy intensity of an economy (Filipović et al., 2014, 2015b; Lin and Liu, 2013; Fisher-Vanden et al., 2004; Hang and Tu, 2007; Chai et al., 2009). Cornillie and Fankhauser (2004) found a direct correlation between energy prices and energy intensity in the transitional countries based on the arithmetic decomposition method. The results showed that two most significant drivers for using energy more efficiently are energy prices and advances in enterprise restructuring.

However, achieving efficient power pricing is easier said than done. As the cost and price of electricity service are influenced by many factors (supply and demand, import diversification, primary fuel price, severe weather conditions, network infrastructure costs, environmental protection costs, charges related to greenhouse gas emission, and excise and taxation rates), these should ideally reflected in prices in order to promote efficient use of electricity. Typically, both the end user and the producer currently base their choices on a lower energy price that does not reflect all the costs to society. Due to low price elasticity of demand in the residential sector, price is not always a solution for effecting energy intensity (Inês et al., 2011; Halvorsen and Larsen, 2011; Filippini, 2011; Blázquez et al., 2012).

This article focuses on energy intensity dynamics in Europe for the period 1990–2015. The purpose is to analyse the energy intensity in the 28 EU member states (EU-28) plus Norway, estimate the size and statistical significance of the effect that electricity price has on energy intensity, taking various control variables into account. The research is focused on the electricity price for residential consumption of 2500–5000 kWh annually, including taxes and charges (more about the methodology can be found at http://ec.europa.eu/eurostat/cache/metadata/EN/nrg_pc_204_esms.htm).

A panel-data model is employed in which the regression parameters are estimated by applying a fixed-effects estimator. The control variables are: GDP per capita, final energy consumption per capita (sum of the energy supplied to the final consumer's door for all energy uses), and dummy variables for structural characteristics and changes of individual economies and regions. In addition, to facilitate the econometric analysis, a statistical analysis is provided for a cross-section sample of 37 European countries EU-28, Norway, and eight Energy Community Treaty countries (Ukraine, Moldova, Serbia, Montenegro, FYR Macedonia, Bosnia and Herzegovina, Kosovo, and Albania) for the latest available year (2015). The Eurostat database was used as a data source due to its reliability, consistency, and relatively long time series for the analysed countries.

This article's main novelty is the econometric analysis that takes into account several control variables, thus obtaining the net effects of electricity price on energy intensity and avoiding specification biases that arise due to an incomplete model specification. The available research in this area tends to be limited in scope (Filipović et al., 2015b), due in part to data availability. This analysis contributes to the literature by covering all EU-28 plus Norway over a relatively long time period.

The article is organized as follows. Section 2 analyses the long-term evolution and structure of household's electricity price and energy intensity in Europe. The data and the research methodology are presented in Section 3. Section 4 conducts the empirical analysis, providing a broad static analysis, an econometric model, and the empirical results. Section 5 gives the main conclusions and policy recommendations, including reflections on possible limitations of the research.

2. Trends in electricity prices and energy intensity in Europe

This section starts with a presentation of structure and dynamics of electricity price for households in EU-28 plus Norway, building on the electricity market liberalisation process and on a methodology of measuring electricity price. Focus is then put on energy intensity dynamics, explaining its developments and describing the energy policy instruments and policies aimed at reducing energy intensity. The list of countries covered in the analysis is given in Table 1.

2.1. Long-term evolution of electricity prices for households in Europe

Since the second half of the 1990s, the EU has taken steps towards liberalisation of its electricity markets. Empirical research of effects of liberalisation and privatisation on electricity price provides mixed evidence. The findings of Fiorio and Florio (2013) suggest a linkage between public ownership and lower electricity prices for households in the EU-15 during a thirty-year period, and limited and less certain influence of liberalisation on prices. Similar research that sampled the same countries and considered the period 1995–2000 suggested that introduction of competition in electricity markets resulted in a significant downward price effects (Martin and Vansteenkiste, 2001). In some EU countries, liberalisation did not lead to an electricity market structure with less concentration and electricity prices have been found to be higher in countries with less concentrated markets (Moreno et al., 2012).

Residential electricity prices (including taxes and charges) in the EU were more or less unchanged until 2003, when they began an upward trend. The reason for their increase was the introduction of greenhouse gas emission allowances in the EU Emissions Trading Scheme (ETS) in 2005 and the greenhouse emission reduction policy promoted since 2005. Also with the aim of promotion of electricity generation from renewable energy sources, EU imposed additional charges that also increase the final electricity price. While the taxes and levies accounted for, on average, 15% of the price in kWh in 1991, their share was 32% at the end of 2011 (Cruciani, 2011). The structure of electricity price for medium residential consumption of 2500–5000 kWh annually (including taxes and charges) is shown in Fig. 1 for the second semester of 2015.

To estimate average prices in the EU, specified prices are combined with national residential consumption. The electricity price that consumers actually pay is affected by electricity tariffs and contract structures, which usually involves many factors, such as established charges and unit prices that differ in relation to the electricity consumed and period of consumption. Residential electricity bills will be impacted by costs associated with energy efficiency policies, renewable energy policies, emissions trading schemes, and investment in infrastructure. On-bill funding for policy priorities in the member states comes from either production or network charges or from taxes or levies, including the value-added tax (VAT) and other taxation instruments. The VAT is the general tax applied to every business activity involved in the