Energy Policy 122 (2018) 592–600

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Household and industrial electricity demand in Europe

Catia Cialani*, Reza Mortazavi

School of Technology and Business Studies, Dalarna University, 791 88 Falun, Sweden

ARTICLE INFO

Keywords:
Electricity demand
Price elasticity
Europe
EU-29
GMM
ML

ABSTRACT

This paper examines the electricity demand, and its determinants, in 29 European countries during the liberalization of the electricity market. Based on panel data for these countries for the years 1995–2015 and using a dynamic partial adjustment model, price elasticities are estimated for both residential and industrial electricity demand. These elasticities and effects of other variables on electricity consumption are estimated using both GMM (generalized method of moments) and ML (maximum likelihood) approaches. It is found that the price elasticities are very small, especially in the short run, while the income elasticities are relatively large, especially for households and in the long run.

1. Introduction

During the last two decades, liberalization of the electricity sector (i.e., opening electricity markets to competition, thereby increasing freedom of choice for consumers) has spread globally. The movement started in a few countries (among others, the United Kingdom, Norway and Australia) in the early 1990s, and was subsequently embraced by other countries including Spain, Germany, and Italy. By the mid-1990s the European Union (EU) was also committed to the process (Directive 96/92/EC).[1] Central objectives of the EU's liberalization policy were to increase welfare by reducing electricity prices for consumers, guarantee security of supply throughout the EU, promote energy efficiency and the use of renewable energy resources, and raise economic efficiency (Willems and Ehlers, 2008). However, contrary to expectations, electricity prices generally increased for most of European countries following liberalization from 1995 to 2015 (Eurostat, 2018). According to economic theory, this should have led to a reduction in electricity consumption, but more information about the interactions involved is required. In particular, knowledge of consumers' sensitivity to changes in electricity prices is extremely important for activities such as reorganizing production, adjusting controls, planning energy or intermediate product storage systems, and provision of appropriate backup capacities or substitute energy sources (Kirschen et al., 2000). Thus, the purpose of this paper is to explore the short- and long-term elasticity of demand for electricity, and determinants of the demand, during the liberalization period in the EU-29 (EU-28 plus Norway). The findings are expected to facilitate efforts to plan and organize electricity supplies robustly and efficiently.

Despite extensive literature on diverse aspects of the electricity sector in the EU and elsewhere, we have found only two studies that include estimates of electricity demand in Europe using panel data. Moreover, these studies only estimated price elasticity in the short-run (ca. 10 years), one covering the period from 1994 to 2004 (Eskeland and Mideksa, 2010) and the other the period from 1990 to 2003 (Azevedo et al., 2011). Most of the other extant literature on electricity demand during the market liberalization period also covers short timeframes. In addition, previous studies focus on electricity demand of residential (household) consumers rather than industrial consumers. Thus, to extend understanding of the demand-side of the electricity market in Europe, thereby facilitating efforts to improve the efficiency of energy services, we identified the following needs. First, to review the empirical literature providing estimates of the price elasticity of electricity demand in panel settings, for both residential and industrial consumers, during liberalization of the EU's electricity sector. Second, to obtain new empirical evidence regarding household and industrial electricity demand in Europe and the associated short- and long-run price and income elasticities. Third, to obtain estimates of these parameters over a sufficiently long time (two decades) to identify other determinants of electricity demand. Finally, to analyze effects of determinants of both residential and industrial electricity demand.

Our analysis is based on a dynamic partial adjustment approach to estimate electricity demand, using aggregate panel data for the EU-29 countries from 1995 to 2015, and both GMM (General Method of Moments) and ML (Maximum Likelihood) modeling. Thus, this paper contributes to the literature by providing an analysis of electricity demand in European countries covering a wider and more recent temporal

* Corresponding author.
E-mail address: cci@du.se (C. Cialani).

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A31996L0092.

https://doi.org/10.1016/j.enpol.2018.07.060
Received 2 April 2018; Received in revised form 29 July 2018; Accepted 31 July 2018

period (during the liberalization process) than previous analyses, at aggregate level and using two distinct econometric approaches. Moreover, to the best of our knowledge, no previous study has examined aggregate industrial electricity demand in Europe. Our study is the first attempt to fill this gap. Our analysis is important for formulating future energy policies, determining future energy requirements and investments, and regulating the activities in the electric market. The results of our analysis will also allow us to draw lessons from the liberalization era in the European countries for both residential and industrial categories of consumers.

The remainder of this paper is organized as follows. Section 2 presents the literature review, and Section 3 a short overview of the electricity market liberalization process. Data and econometric models are presented in Section 4, while results are discussed in Section 5. Finally, concluding remarks are presented in Section 6.

2. Literature review

This section reviews the empirical literature on electricity demand, particularly literature including estimates of price and income elasticities. Some studies focus on a single company or country, while others consider data from several countries. Here, we are mainly interested in studies based on aggregate datasets. There are large variations in estimated short- and long-run price elasticities presented in recent studies, likely due to differences in the time periods covered, and in both the types of datasets (time series vs. panel data) and econometric approaches used. We also briefly discuss some methodologies that have been applied.

2.1. Household electricity demand

There is extensive empirical literature on household electricity demand, which is generally estimated by one of two approaches. The first is to use aggregate data, usually including data on price and income variables along with various other factors such as climate and urbanization. Filippini (1999), García-Cerruti (2000), Hondroyiannis (2004), Holtedahl and Joutz (2004) and Narayan and Smyth (2005) use this kind of specification for analyzing residential electricity demand. In the second approach, survey data are used to estimate residential electricity demand and consider effects of potential explanatory variables, such as housing characteristics, use of appliances, and household demographics. Baker et al. (1989), Leth-Petersen (2002), Larsen and Nesbakken (2004), and Filippini, and Pachauri (2004) all use this method. Previous studies on household electricity demand have provided widely varying indications of its responsiveness to price and income. As summarized in Table 1, recent estimates of the price elasticities for household electricity demand vary between − 0.05 and − 1.27 in the short-run, and between − 0.19 and − 1.06 in the long-run.

Regarding the econometric approach, most previous authors have employed either static models or dynamic partial adjustment models. Eskeland and Mideksa (2010) used a static model of residential electricity demand in 30 European countries to study effects of temperature changes on electricity consumption. Azevedo et al. (2011) also estimated residential electricity demand using static models applied to two panel datasets (one covering 15 EU countries from 1990 to 2003 and the other covering US states from 1990 to 2004), yielding short-run price elasticities of − 0.2 and − 0.21 to − 0.25, respectively. More recently, Cebula (2012) estimated residential electricity demand in US states between 2002 and 2005 using a two-stage least squares approach. Results include findings that residential electricity consumption declined with adoption of energy efficiency programs, increases in price, annual cooling degree days and per capita real disposable income.

Authors who have used dynamic models for energy demand include Bernstein and Griffin (2006) and Paul et al. (2009), although they did not address the potential dynamic panel bias that arises by including the lag of consumption. Both studies estimate residential electricity demand in the USA. Using data covering 1977–2004, Bernstein and Griffin (2006) obtained short and long-run price elasticities of − 0.24 and − 0.32 respectively. The study by Paul et al. (2009) covered the years 1990–2004, and derived estimated short- and long-run price elasticities of − 0.13 and − 0.40 respectively. They claimed that attempts to account for the lag of consumption (which introduces dynamic panel bias) were unsuccessful and resulted in unstable estimates. Therefore, they only reported least squares dummy variable (LSDV) estimates. However, some recent studies have accounted for dynamic panel bias and used more advanced dynamic panel data models, e.g., panel cointegration, autoregressive distributed-lag (ARDL) or (GMM) estimators. Narayan et al. (2007) used a panel cointegration technique to estimate residential electricity consumption in G7 countries, obtaining group-mean estimates indicating an elastic price effect (− 1.56) and inelastic income (0.245) effect. In contrast, Dergiades and Tsoulfidis (2008), Hung and Huang (2015), and Nakajima (2010) found residential electricity demand to be income inelastic and price elastic. Dergiades and Tsoulfidis (2008) also estimated residential electricity demand in the USA using the ARDL panel cointegration approach and, in contrast to Narayan et al. (2007), detected a significant price effect. They estimated a short-run price elasticity of − 0.39 and long-run income and price elasticities of 0.27 and − 1.07, respectively. Bernstein and Madlener (2015) analyzed residential electricity demand in 18 OECD countries from 1981 to 2008 using panel cointegration and Granger causality testing. They found a short-run price elasticity of − 0.1, and a long-run elasticity of − 0.39. Lower values (− 0.07 and −

Table 1
Previously published estimates of short- and long-run price elasticities of household electricity demand obtained from panel data models.

Study	Time period	Panel	Price elasticity	
			Short-run	Long-run
Narayan et al. (2007)	1978–2003	G-7		− 1.06
Dergiades and Tsoulfidis (2008)	1956–2006	US	− 0.39	− 1.07
Tanishita (2009)	1986–2006	Japan	0.5–0.9	1.0–2.07
Paul et al. (2009)	1990–2004	US	− 0.13	− 0.40
Eskeland and Mideksa (2010)	1994–2005	Europe	− 0.2	
Nakajima and Hamori (2010)	1975–2005	US	− 0.14 to − 0.33	
Azevedo et al. (2011)	1990–2004	US	− 0.21 to − 0.25	
	1990–2003	EU-15	− 0.2	
Bernstein and Madlener (2011)	1981–2008	OECD	− 0.05 to − 0.06	− 0.39
Alberini and Filippini (2011)	1995–2007	US	− 0.08 to − 0.15	− 0.44 to − 0.73
Blazquez et al. (2013)	2000–2008	Spain	− 0.07	− 0.19
Okajima and Okajima (2013)	1990–2007	Japan	− 0.4	− 0.49
Hung and Huang (2015)	2007:01–2013:12	Taiwan	− 1.14 to − 1.13 − 0.85 to − 1.27	