ENERGY
POLICY

Electricity consumption in G7 countries: A panel cointegration analysis of residential demand elasticities

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Abstract

This article applies recently developed panel unit root and panel cointegration techniques to estimate the long-run and short-run income and price elasticities for residential demand for electricity in G7 countries. The panel results indicate that in the long-run residential demand for electricity is price elastic and income inelastic. The study concludes that from an environmental perspective there is potential to use pricing policies in the G7 countries to curtail residential electricity demand, and thus curb carbon emissions, in the long run.

1. Introduction

In 2005 the G7 countries together generated over 40% of the world's electricity and were major contributors to carbon dioxide emissions worldwide (BP, 2006). Growing concerns over the effects of greenhouse gas emissions for global warming have placed pressure on the world's leading economies to improve the efficiency of energy use. An initial response from the G7 to concerns about efficient electricity use was the formation of the E7, a nonprofit group comprised of nine leading electricity companies from the G7 in the wake of the Rio Summit in 1992 with the objective of promoting sustainable energy development.[1] More recently, attention has been focused on obligations under the Kyoto Protocol which came into operation in February 2005. Under the Kyoto Protocol, the developed countries agreed to limit their greenhouse gas emissions relative to the levels emitted in 1990. While

the United States has not ratified the treaty, it has also agreed to reduce emissions from its 1990 levels by 7% between 2008 and 2012. Economists have long argued that pricing policies are an effective instrument to improve the efficiency of energy use; however, the effectiveness of pricing policies to promote the efficient use of electricity depends on the price elasticity of demand for electricity.

The objective of this article is to provide estimates of the income and price elasticities of G7 residential electricity demand. A methodological contribution of the study is that it employs a panel unit root and panel cointegration framework that takes into account the time series properties of the data. Recent studies have applied a panel unit root and panel cointegration framework to examine whether there is a long-run relationship between energy demand and real income for various groupings of countries (see Lee, 2005; Al-Iriani, 2006; Joyeux and Ripple, 2007), but this has not been done before in estimates of the residential electricity demand equation. There are a few studies that have estimated income and price elasticities for residential electricity within a panel framework utilizing pooled cross-sectional and time series state-level data within the United States (see e.g. Houthakker et al.,

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[1]In June 2006 the E7 expanded to become the E8, adding the electricity companies of Russia.

1974; Houthakker, 1980; Hsing, 1994). These studies, however, have not first tested whether the panel data are stationary, so the findings are potentially spurious. To test whether there is a long-run relationship between residential electricity demand and its determinants, the panel cointegration test of Pedroni (2004) is used which has the advantage that it allows for heterogeneity across countries. To estimate the long-run elasticities, we use ordinary least squares (OLS) as well as dynamic OLS (DOLS).

The rest of the article is organized as follows. In the next section an overview of economic performance and electricity generation in the G7 is provided. In Section 3, we present a brief review of the existing literature. The empirical model to be estimated is discussed in Section 4. In Section 5 the econometric methodology employed is discussed. The penultimate section presents the empirical results, while the final section concludes.

2. Economic growth, electricity and carbon dioxide emissions in the G7

The G7 countries are the major developed countries in the world. Fig. 1 presents data on real income per capita in the G7 since the late 1970s expressed in United States dollars. Japan has had the highest real income per capita of the G7. In 1980 real GDP per capita in Japan was US$28,234 and by 2003 this had increased to US$45,589. Germany and the United States have the second and third highest real income per capita in the G7 over the period, increasing from US$22,602 in 1980 to US$33,085 in 2003 and US$20,954 in 1980 to US$32,623 in 2003, respectively. France is in fourth place, with a slightly lower real income per capita than the United States and then there is a clear gap to Canada, the United Kingdom and Italy. Fig. 2 shows the growth rate in real GDP per capita for the G7 countries between 1960 and 2005. Periods of relatively high economic growth are punctuated by recessions associated with the oil price shocks in 1973–1974 and 1981–1982 and the recession of the early 1990s. Japan stands out as having above average economic growth in the 1960s and slower economic growth since the early 1990s.

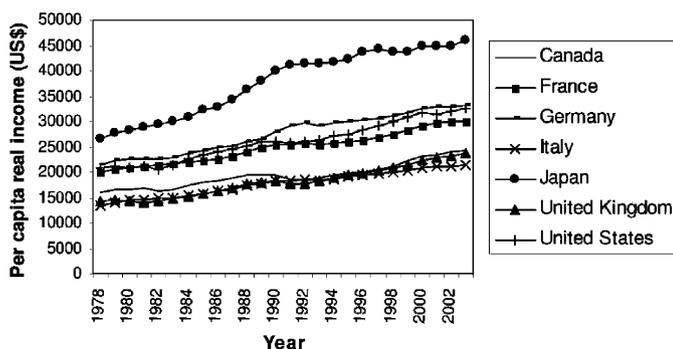Fig. 3 shows electricity generated in the G7 countries as a percentage of the world total. Between 1990 and 1995, as a whole the G7 countries generated over 50% of the world's electricity. There has been a slight downward trend since 1995, although in 2005 the G7 together still generated 43% of the world's electricity. The United States is the largest generator of electricity in the world, consistently accounting for about one quarter of the world's electricity. Japan generates 6–7% of the world's electricity, while Canada, France and Germany each generate 3–4% of the world's electricity. Figs. 4 and 5 show residential electricity and gas prices in the G7 countries since the late 1970s. There is a sizeable variation in electricity prices across the G7. Since the 1970s, electricity prices have been the lowest in Canada, the United States and the United Kingdom and the highest in Italy, Japan and Germany. In contrast, gas prices have been similar across the G7 countries. There is a sharp increase in gas prices following the first oil price shock in 1981, followed by a gradual downward trend since 1985.

Fig. 6 shows carbon dioxide emissions per capita in the G7 countries between 1960 and 2002. The United States, Canada, Germany and the United Kingdom have the highest carbon dioxide emissions per capita in the G7 and all are above the average for high-income countries. By contrast, the other G7 countries are below the average for high-income economies. Together with countries such as Australia and a handful of countries in the Gulf States, the United States, Canada, Germany and the United Kingdom are among the highest emitters of carbon dioxide on a per capita basis in the world. For the United States, carbon dioxide emissions increased from 16.20 metric tons per capita in 1960 to 20.23 metric tons per capita in 2002. For Canada, the corresponding increase over this period was 10.76 to 16.46 metric tons per capita. Carbon dioxide emissions in the United Kingdom have exhibited a slight decrease from 11.15 metric tons per capita in 1960 to 9.15 metric tons per capita in 2002, while carbon dioxide emissions in Germany have decreased from 12.34 metric tons per capita in 1990 (the first year for which data are available) to 10.30 metric tons per capita in 2002.

3. Existing literature

There are several studies of the determinants of the residential demand for electricity in individual G7 countries. There are studies for Canada (see e.g. Bernard et al., 1996); the United States (see e.g. Houthakker et al., 1974; Houthakker, 1980; Hsing, 1994; Silk and Joust, 1997) and the United Kingdom (see e.g. Dodgson et al., 1990; Henley and Peirson, 1999; Clements and Madlener, 1999). For countries outside the G7, there are studies of the residential demand for electricity in Asia–Pacific countries, such as Australia, India and Taiwan (see e.g. Narayan and Smyth, 2005; Filippini and Pachauri, 2004; Holtedahl and Joutz, 2004); European countries, such as Greece, Norway and Switzerland (see e.g. Donatos and Mergos, 1991; Ettestol, 2002; Filippini, 1999) and countries in the Middle East (see e.g. Al-Faris, 2002; Beenstock et al., 1999; Eltony and Hoque, 1996; Nasr et al., 2000).

Fig. 1. G7 real income per capita 1978–2003. *Source*: OECD (2005).