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Economic growth-electricity consumption causality in 12 European countries: A dynamic panel data approach

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ABSTRACT

This paper applies recent panel methodology to investigate the long-run and causal relationship between electricity consumption and real GDP for a set of 12 European countries using annual data for the period 1970–2007. The sample countries have moved faster than other neighboring countries towards the creation of a single electricity market over the past 30 years. Energy prices are also included in the study due to their important role in affecting the above variables, thus avoiding the problem of omitted variable bias. Tests for panel unit roots, cointegration in heterogeneous panels and panel causality are employed in a trivariate VECM estimated by system GMM. The results show evidence of a long-run equilibrium relationship between the three series and a negative short-run and strong causality from electricity consumption to GDP. As expected, there is bidirectional causality between energy prices and GDP and weaker evidence between electricity consumption and energy prices. These results support the policies implemented towards the creation of a common European electricity market.

1. Introduction

The relationship between electricity consumption and economic growth is an area of interest in energy economics literature. There are two main reasons that have fostered an increasing interest in the field. One is the oil price increase in the 1970s and 1990s and the other is the increasing dependency on fossil fuel imports by developed and some developing countries. Several solutions have been proposed to mitigate the potential negative effects of these two factors on economic growth. These include increases in energy efficiency, improvement of infrastructures, R&D investments and effective enforcement of competition law and regulation.

These challenges are shared by European countries, among others. At the end of 2005, the European Heads of State and Government called for a true European energy policy. This led to the European Commission publishing a Green Paper (A European Strategy for Sustainable, Competitive and Secure energy, 2006) on 8 March 2006 on the development of a "common, coherent European Energy Policy". The Green Paper also set out to help the European Union (hereafter, EU) to achieve efficient use of energy resources, security, competitive markets and sustainable energy development. In particular, said security of energy procurement is recognized as a necessary condition for a balanced growth path to be followed. Under this scenario, electricity plays a key role. Therefore, empirical analysis on the causal relationship between electricity consumption and economic growth seems to be particularly important as, once we control for price fluctuations, it will be helpful to design optimal electricity programs based on the spirit of the Green Paper.

If electricity consumption causes economic growth, then policies encouraging a reduction in electricity consumption will have an effect on growth. If electricity consumption does not cause economic growth or economic growth causes consumption, then electricity conservation policies will have no impact on growth. Finally, if results suggest that there is a mutual relationship between electricity and Gross Domestic Product (GDP), then any global policy to reduce electricity consumption in order to reduce emissions would have an impact on the GDP of overall countries.

Several studies have examined the relationship between energy or electricity consumption and economic growth at country level (see Altinay and Karagol, 2005; Lee and Chang, 2005; Soytas and Sari, 2003; Oh and Lee, 2004; Yoo, 2005; Ciarreta and Zarraga, 2009, among others). However, the main failure of these studies is that the time series sample size is usually small, so the results of the econometric tests might be not reliable.

As a possible solution, panel data techniques have been used to analyze the dynamic relationship. Many studies use the two-step procedure from Engle and Granger (1987) in a panel-based error

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correction model. To name some of them, Lee (2005) finds evidence of causality running from energy consumption to GDP for a panel of 18 developing countries in the period 1975–2001; Lee et al. (2008) find a bi-directional causal relationship between energy consumption, capital stock and GDP for 22 OECD countries covering the period 1960–2001 and Lee and Chang (2008) consider 16 Asian countries for the period 1971–2002 and find evidence of long-run unidirectional causality running from energy consumption to GDP.

Other studies estimate a panel VAR model using the techniques developed by Holtz-Eakin et al. (1988) and Arellano and Bond (1991). Among others, Lee and Chang (2007) find evidence of causality from GDP to energy consumption in a sample of 18 developing countries and bidirectional causality in a sample of 22 developed countries and Al Iriani (2006) finds a unidirectional causality from GDP to energy consumption for panel data on the six countries of the Gulf Cooperation Council in the period 1971–2002. More recently, Huang et al. (2008) estimate a panel VAR model using system GMM approach, which provides a more efficient estimator. They divide a sample of 82 countries for the period 1972–2002 into four groups according to their income levels and find different results depending on the group considered.

Panel estimation techniques have been applied to a lesser extent to study the dynamic relationship between electricity consumption and GDP. Chen et al. (2007) choose a sample of 10 developing countries in Asia. Using a panel-based error correction model, they find significant long-run causality in both directions and uni-directional short-run causality running from economic growth to electricity consumption. Böhm (2008) considers a sample of 15 EU countries and tests for the long-run relationship between the variables in question. However, the existence and direction of causality in the short- and long-run is tested at country-level by using vector error correction models and Granger causality tests.

Our study focuses on the relationship between economic growth and electricity consumption, controlling for energy price fluctuations in 12 European countries which have moved faster than in other neighboring countries towards the creation of a single electricity market over the past thirty years.

The methodology includes testing for unit roots, cointegration and a dynamic panel estimation approach to identify the Granger causal relation in our panel data. The use of panel techniques enables the power of the tests to be increased and makes it possible to include heterogeneity between countries. We thus overcome some of the problems associated with single country studies. However, the use of panel data implies that the different countries are treated as a unity and as such the results represent those of the average member of the panel. Country specific effects are lacked, thus in the following section we explain the criterium for the selection of the sample countries. Due to the important role of energy prices in affecting electricity consumption and economic growth, energy prices are included in the study, thus avoiding the problem of omitted variable bias. Therefore, we consider a trivariate panel vector error correction model (VECM) and estimate it using system GMM as in Huang et al. (2008). This methodology provides more efficient estimators than in Arellano and Bond (1991) when using lagged differenced dependent variables as instruments (see Blundell and Bond, 1998). To our knowledge, there is no other study of that relationship for these countries and these three variables.

The rest of the paper is structured as follows. Section 2 describes the data and provides arguments to justify the choice of the countries used in the study. Section 3 explains the panel methodology. Section 4 summarizes empirical results. Section 5 concludes and proposes some policy implications that emerge from the study.

2. Data

The target of an Internal Energy Market had already been put in place by 1988 and it led to legislation that aimed to create a single European market for electricity and gas (see Chapter XV of the Treaty of the European Union, articles 154, 155 and 156). Shortly afterwards, Scandinavian countries created the Nordpool, which currently includes Norway, Denmark, Finland and Sweden. Regulatory frameworks, including Switzerland, were eventually normalized. The Priority Interconnection Plan proposes the main actions to ensure a stable environment that should favor investments. Among others, it explicitly recognizes that power links between France and Spain (and by extension Portugal), Germany and Eastern Europe are still weak, Greece remains isolated from neighboring countries. Finally, UK and Ireland have low levels of interconnections.

Taking into account the previous argument, we consider 12 European countries that have moved towards this target. The sample comprises 10 EU countries: Austria, Belgium, Denmark, Finland, France, Germany, Italy, Luxembourg, Netherlands and Sweden, and two non-EU countries: Norway and Switzerland, which is an important electricity transit country. The other EU members can be included in two groups: UK, Ireland, Spain, Portugal and Greece are countries that by their characteristics are quite isolated in terms of interconnections; and the new members from Eastern Europe are far from reaching the target.

The magnitude of the interconnections between the sample countries is summarized in Table 1. Columns 2 and 4 show the average shares of imports and exports, respectively, from total electricity consumption. Columns 3 and 5 show the average shares of imports and exports, respectively, from total electricity consumption within the sample countries.

On average the share of imports (exports) from total consumption is 12.1% (11.0%) between the sample countries out of a total of 14.1% (12.9%). There are differences in the pattern of trading between countries. The net selling position of electricity is not determined only by resource availability but also by the structure of electricity generation. For example, Italy is clearly a net importer of electricity whilst France is a net exporter. The former relies heavily on non-nuclear capacity whereas the latter uses mainly nuclear generation. Switzerland, and to a lesser extent Austria, are at the heart of central Europe and they are used for electricity transmission between central Europe and Italy.

Table 1
Interconnections.[a]

	% Imports		% Exports	
	Of total	Of sample	Of total	Of sample
Austria	24.7 (6.8)	18.1 (5.1)	22.9 (4.2)	18.1 (3.6)
Belgium	19.1 (3.6)	19.1 (3.6)	11.3 (1.3)	11.3 (1.3)
Denmark	27.1 (11.2)	27.1 (11.2)	29.7 (13.0)	29.7 (13.0)
Finland	14.9 (4.1)	9.1 (3.6)	2.8 (2.6)	2.1 (1.7)
France	4.2 (0.6)	3.9 (0.3)	19.6 (1.5)	14.4 (1.1)
Germany	15.2 (17.2)	12.1 (11.2)	10.1 (2.6)	9.1 (2.0)
Italy	16.8 (0.9)	14.9 (0.6)	0.3 (0.1)	0.2 (0.1)
Luxembourg	116.2 (5.6)	116.2 (5.6)	30.6 (15.6)	30.6 (15.6)
Netherlands	17.0 (4.6)	17.0 (4.6)	3.6 (1.9)	3.6 (1.9)
Norway	8.1 (4.6)	8.0 (4.6)	9.5 (4.7)	7.1 (4.7)
Sweden	11.3 (4.1)	11.3 (4.1)	14.1 (3.6)	15.1 (3.6)
Switzerland	48.7 (9.6)	48.7 (9.6)	58.1 (5.5)	58.1 (5.5)
Mean[b]	14.1 (16.6)	12.1 (11.2)	12.9 (12.7)	11.0 (10.7)

[a] Standard deviations in parentheses. Source: IEA and own work.
[b] Weighted mean by total electricity consumption in each country.