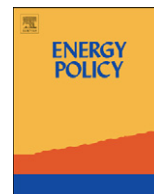




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Electricity consumption and economic growth nexus in Portugal using cointegration and causality approaches

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ABSTRACT

The aim of this paper is to re-examine the relationship between electricity consumption, economic growth, and employment in Portugal using the cointegration and Granger causality frameworks. This study covers the sample period from 1971 to 2009. We examine the presence of a long-run equilibrium relationship using the bounds testing approach to cointegration within the Unrestricted Error-Correction Model (UECM). Moreover, we examine the direction of causality between electricity consumption, economic growth, and employment in Portugal using the Granger causality test within the Vector Error-Correction Model (VECM). As a summary of the empirical findings, we find that electricity consumption, economic growth, and employment in Portugal are cointegrated and there is bi-directional Granger causality between the three variables in the long-run. With the exception of the Granger causality between electricity consumption and economic growth, the rest of the variables are also bi-directional Granger causality in the short-run. Furthermore, we find that there is unidirectional Granger causality running from economic growth to electricity consumption, but no evidence of reversal causality.

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1. Introduction

Examination of the relationship between electricity consumption and economic growth is not a novel area of exploration; it has been researched extensively over the past decades. Nevertheless, the causality direction between electricity consumption and economic growth remains contradictory. Some empirical studies (e.g. Ghosh, 2002; Mozumder and Marathe, 2007) claimed that economic growth Granger-causes electricity consumption, while many studies argued that electricity consumption Granger-causes economic growth because electricity is an essential factor of production (e.g. Stern, 1993; Yuan et al., 2007; Tang, 2008, 2009). Determination of its causality has important policy implications (Jumbe, 2004; Squalli, 2007). If the causality direction runs from economic growth to electricity consumption or neutral causality, environmental policies for electricity conservation would not adversely affect economic growth. On the other hand, if the Granger causality direction runs from electricity consumption to economic growth, environmental policies to conserve electricity consumption may weaken the economic growth and development. Hence, it is a debatable issue in the economics of

energy and is important to re-investigate empirically the relationship between electricity consumption and economic growth.

A literature review suggests that there is a lack of empirical study concerning the relationship between electricity consumption and economic growth in Portugal. To the best of our knowledge, only two studies have considered it. First, Narayan and Prasad (2008) conducted a study on this area for 30 OECD countries, but no attention was paid to explaining the presence of a long-run equilibrium relationship. They only focused on the direction of causality between electricity consumption and economic growth by using the bootstrapping Granger causality approach. In addition, they found evidence of unidirectional causality running from electricity consumption to economic growth in Portugal. Second, Chontanawat et al. (2008) investigated the relationship between energy consumption (kg of oil equivalent per capita) and economic growth over 100 developing countries (i.e. OECD and non-OECD) using the Johansen's cointegration and Hsiao's (1981) version of Granger causality approaches. Remarkably, they also found that energy consumption Granger-causes economic growth in the case of Portugal, but the variables are not cointegrated. Masih and Masih (1996) argued that the Granger causality test is strictly a predictability rather than a causality effect if the variables are not cointegrated. Hence, it is a must to examine the presence of cointegration to affirm the validity of causal relationship. Apart from that, existing

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studies on this topic in Portugal tend to focus on a bivariate framework, which may be biased owing to the omission of relevant variables (Chang et al., 2001; Narayan and Smyth, 2005). Thus, the results of a Granger causality test based on a bivariate framework are likely to be biased (Lütkepohl, 1982).

Against these backdrops, this study attempts to re-investigate the relationship between electricity consumption and economic growth in Portugal by incorporating employment as a control variable.¹ In doing so, this study may avoid the omitted variable(s) bias and the results should be more reliable. At best, this will be the first study on electricity consumption-growth nexus in Portugal using a multivariate framework. Apart from modelling, another contribution of this study is to examine the presence of a long-run equilibrium relationship using the bounds testing approach to cointegration within the UECM framework (Pesaran et al., 2001).² Although many studies stated that the bounds testing approach to cointegration is suitable for a small sample, the critical values provided by Pesaran et al. (2001) are for a relatively large sample (Narayan, 2005; Turner, 2006). Therefore, we employ the surface response procedure developed by Turner (2006) to compute a set of critical values for a small sample to enhance the robustness of the cointegration results. Next, this study will employ the Granger causality test within the Error-Correction Model (ECM) to ascertain the causal relationship among electricity consumption, economic growth, and employment in Portugal. The advantage of using the conventional ECM Granger causality test is that it allows us to measure or differentiate the short- and long-run causal relationship, if any. Therefore, it will provide better information for policymakers in formulating short- and/or long-run policies.

The rest of this paper will be organised as follows. Section 2 will review the Portuguese context of electricity consumption and economic growth. The literature review will be presented in Section 3. Section 4 will discuss the data and econometric techniques employed by this study. The empirical results and conclusion will be reported in Sections 5 and 6, respectively.

2. Portuguese context

Portugal is a country located in Southern Europe, comprised of a continental area and two insular zones (i.e. the Azores and Madeira). In 2010, it consists of surface area of 92,000 square kilometres and approximately 10.7 million inhabitants in the economy. The Portuguese economy is the choice for this study because of the following characteristics. Since joining the European Union (EU) in 1986, the Portuguese economy has been growing steadily and has diversified to a services-based economy, such as the telecommunications, finance, transportation, and energy sectors, to increase international competitiveness and further spur economic growth. From late nineties to early noughties, Portugal was one of the rapidly growing countries among the EU members. Although the Portuguese economy has a relatively small energy market and limited domestic energy resources, the rapid increase in the aforementioned sectors have placed significant pressure on electricity consumption. In addition, the infrastructure improvements such as the transportation network and modernisation of the country's ports have caused an increase

in electricity consumption in Portugal (Brown, 2002). Evidently, in 2007, the Portuguese economy ranked as the 47th top electricity user in the world.

Fig. 1 shows that electricity consumption per capita in kilowatt hour (kWh) and real GDP per capita in Portugal moved with an upward trend over the period 1971–2009. This implies that electricity could be one of the major inputs for economic growth and development in Portugal. Since 1990, electricity consumption per capita in Portugal has grown faster than its real GDP per capita. For example, electricity consumption was 4013.96 kWh per capita in 2000, up by 56.5% from the 1990 level (2564.27 kWh per capita), while over the same period, real GDP per capita grew by about 28.6% from USD9295.17 million per capita to USD11,957.01 million per capita. According to IEA (2004), the significant increase in electricity consumption may be due to the increasing use of air-conditioning and other electrical appliances by the residential sector in Portugal. Air-conditioning use in Portugal has been increasing steadily at approximately 500,000 new units installed annually and this trend is expected to continue for several years. Moreover, the breakdown of electricity consumption by sectors in Table 1 shows that electricity consumption by residential and other sectors (i.e. commercial, public services, and agricultural sectors) increased rapidly from 33.3% in 1970 to 62.5% in 2008. On the other hand, electricity consumption by industry sector declined from 66.7% in 1970 to approximately 37% in 2006 until 2008. Similarly, electricity consumption by transportation sector dropped from 3.7% in 1970 to 1.5% in 1990 and then it fluctuates around 1% from 2000 until 2008.

Electricity in Portugal is generated by a combination of fossil fuel and renewable energies, such as coal, oil, gas, hydropower, biomass, and wind power. Owing to the scarcity of domestic energy resources and in order to corroborate with the EU directive on renewable electricity (2001/77/EC), the Portuguese government has focused on the expansion of renewable energy by launching the E4 programme (i.e. Energy Efficiency and Endogenous Energies) in 2001. For this reason, Portugal made considerable efforts in strengthening its energy policy by promoting renewable energy, improving energy efficiency, and bringing more competition into the energy markets. In 2003, fossil fuel supplied about 62% of total electricity generation, while the remaining 38% was supplied by renewable energy (IEA, 2004). Remarkably, nearly 45% of electricity generation in 2010 has come from renewable sources, compared to 17% in 2005 (Rosenthal, 2010). Historically, Portugal was highly dependant on imported fossil fuels, but Portugal has now become a leader in renewable energy development in the areas of hydro, wind, solar, and other renewable energy technologies (IEA, 2009). Therefore, it is interesting to establish an empirical study on electricity consumption and economic growth nexus for Portugal.

3. A brief review of literature

By reviewing the energy literatures, it is clear that the relationship between electricity consumption and economic growth has been examined extensively since the work of Kraft and Kraft (1978). However, the direction of causality between electricity consumption and economic growth remains controversial. Generally, empirical studies on the relationship between electricity consumption and economic growth can be divided into two major groups. The first group focused on country-specific studies, while another group focused on multi-country studies. Table 2 shows a summary of the selected empirical studies on the electricity consumption-growth nexus.

We begin our discussion with the findings of country-specific studies in the literature of electricity consumption-growth nexus.

¹ We appreciate the anonymous reviewers' helpful suggestion of this control variable.

² Karanfil (2009) noted that using the conventional tests merely increases the number of conflicting findings and jeopardises the reliability of the policy implications. In an energy-growth literature survey, Ozturk (2010) suggested employing the bounds testing approach to cointegration to yield more robust results.

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