



# The electricity consumption and economic growth nexus: Evidence from Greece



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## HIGHLIGHTS

- We examine the causality between electricity consumption and economic growth.
- We used cointegration techniques to capture short-run and long-run dynamics.
- The relationship between electricity consumption and GDP is bi-directional.
- Residential energy switching in Greece is still limited.
- The implementation of renewable energy sources should ensure security of supply.

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## ABSTRACT

This paper attempts to cast light into the relationship between electricity consumption and economic growth in Greece in a multivariate framework. For this purpose we used cointegration techniques and the vector error correction model in order to capture short-run and long-run dynamics over the sample period 1970–2011. The empirical results reveal that in the long-run electricity demand appears to be price inelastic and income elastic, while in the short-run the relevant elasticities are below unity. We also argue that the causal relationship between electricity consumption and economic growth in Greece is bi-directional. Our results strengthen the notion that Greece is an energy dependent country and well directed energy conservation policies could even boost economic growth. Furthermore, the implementation of renewable energy sources should provide significant benefits ensuring sufficient security of supply in the Greek energy system. This evidence can provide a new basis for discussion on the appropriate design and implementation of environmental and energy policies for Greece and other medium sized economies with similar characteristics.

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## 1. Introduction

The relationship between energy consumption and economic growth has been the subject of thorough research and of great interest to economists as well as to policy makers. Knowledge of the actual causality direction between electricity consumption and income growth has important implications for modeling environmental and growth policies. More specifically, if the causality runs from income growth to electricity consumption, then environmental policies for electricity conservation may not affect income growth. On the other hand, if there is a positive causality running from electricity consumption to income growth, then environmental

policies aimed at conserving electricity consumption may negatively affect economic growth and development (Tang and Tan (2012)).

During the last few years, there is a substantial body of literature assessing the determinants and the direction of causality between economic growth and energy consumption. However, the bulk of the literature has so far offered conflicting and inconsistent results concerning the causal relationship between energy consumption and economic growth (Hondroyannis et al., 2002). Although, the empirical evidence in a study over 100 countries (Ferguson and Wilkinson, 2000) shows a strong correlation between them, this does not necessary imply a causal relationship. The evidence concerning the causality is ambiguous, from bi-directional (in both directions) and uni-directional (from energy consumption to economic growth or the opposite) to no causality. Another extensive study (Payne, 2010) provides a survey of the international evidence on the causal relationship between energy consumption and economic growth, where the empirical results

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are again mixed concerning the causality, even for a specific energy carrier such as the electricity. The variation in results may be attributed to variable selection, model specifications, time periods of the studies, different institutional, structural frameworks in the countries examined, and econometric approaches undertaken (Hondroyannis et al., 2002; Payne, 2010).

Despite the fact that the relationship between energy consumption and economic growth has been extensively studied over the past three decades, the development of new energy and environmental policies, the new climate regime and the development of new econometric techniques provide enough space for further research. The initial interest in the causality of this relationship, not only in the demand side but also in the production side, was triggered mainly by the energy crises in the 1970s. This has created doubts on the conventional neoclassical production function, where Land, Labor and Capital were recognized as the main factors of production (Obas John, 1996). The energy crises together with fast technological developments have created space for examining the relationship of the energy factor and of endogenous technological change in economic growth.

Over the last two decades, the advance of econometric techniques together with the new climate regime created space and stimulated further empirical research. The increase of global awareness on climate change issues, enhanced mainly through the introduction of the Kyoto Protocol, has placed pressure on designing energy and environmental policies with low marginal abatement costs. Energy efficiency projects have been prioritized in the portfolio of policies for many countries, as those policies have been considered as no regret options, meaning that they provide even gains in the macro-economy. Estimates of the effects of no-regrets efficiency policies have been reported by the International Energy Agency (IzEA WEO, 2006), and synthesized in the IPCC AR4 WG3 report (IPCC AR4, 2007), using detailed bottom-up models but creating also need for examining from a top-down approach.

Therefore, examining the impact of energy efficiency policies on economic growth became a crucial task among researchers and policy makers. Moreover, the extent of the implementation of energy efficiency measures has created doubts on the extent of the rebound effect, which refers to the idea that some or all of the expected reductions in energy consumption as a result of energy-efficiency improvements are offset by an increasing demand for energy services, arising from reductions in the effective price of energy services resulting from those improvements (Barker et al., 2009). This rebound effect is highly influenced by the level of environmental awareness, as a behavioral shift can lock-in or even accelerate the effects of energy savings projects.

The need for directing specific policies has led to the development of “bottom-up” detailed models and on the disaggregation of econometric studies. Recent research does not focus on aggregate energy demand consumption but on specific sectors (Rapanos and Polemis, 2006; Polemis, 2006; 2007; Wolde-Rufael, 2004) and/or on disaggregated energy demand and specific energy carriers (Hu and Lin, 2008; Tang and Tan, 2012; Chandran et al., 2010; Yuan et al., 2007; Altinay and Karagol, 2005) and/or on countries with specific characteristics (Wolde-Rufael, 2009; Narayan and Smyth, 2008; Lee and Chang, 2008). Again in the above mentioned studies, the causality between disaggregated energy demand and economic activity is ambiguous.

The causality between energy consumption and economic growth is ambiguous among countries (Ozturk, 2010; Payne, 2010; Wolde-Rufael, 2004) or even among studies for the same country, as each country has its own institutional, structural characteristics, different exposure in foreign energy resources and therefore different exposure in energy supply crises, different climatic conditions and behavioral patterns.

Over the last few decades a number of empirical studies for the Greek economy investigated energy demand relationship with economic growth and prices. They have shown mixed results, either observing falling income and price elasticities of energy demand (Samouilidis and Mitropoulos, 1984), either concluding that elasticities behave as a cluster against energy demand (Mitropoulos et al., 1982), either showing that energy demand is rather inelastic with respect to prices (Donatos and Mergos, 1989; Donatos and Mergos, 1991; Christodoulakis and Kalyvitis, 1997; Zonzilos and Lolos, 1996) or showing a bi-directional causality between energy demand and economic growth (Hondroyannis et al., 2002). Other studies (Polemis, 2006, 2007) have examined this causality between energy demand and economic growth, but focused on specific sectors of the economy.

However most of those studies have one or more of the following three main shortcomings: they have not focused on the possible interdependence between energy demand and economic activity, failing therefore to catch the notion of causality and possible rebound effects. They have focused on bivariate or trivariate variable models, and finally they have not focused on electricity consumption. The purpose of this paper is not to resolve this variation in causality, but to provide new evidence and reinvestigate the notion of causality for Greece, considering the latest available data. On the one hand, our aim is to focus on the causality between the electricity demand and the economic growth in a multivariate framework, while on the other hand the novelty of this paper concerns the investigation of the dynamic interactions between the electricity consumption and its main determinants. This can provide a new basis for discussion on the appropriate design and implementation of environmental and energy policies for Greece and other medium-sized economies with similar characteristics.

The rest of the paper is organized in the following way. Section 2 briefly reviews the structure of the electricity sector in Greece. Section 3 deals with methodological issues and the data used in the empirical analysis, while in Section 4 the empirical evidence is presented. Finally, in Section 5, the conclusions of the analysis are summarized and policy implications are discussed.

## 2. The electricity sector in Greece

The liberalization process of the Greek electricity market started with the law 2773/1999, through which market participants, by obtaining the appropriate Licenses, are enabled to participate in one of the following separate activities: production, trading and supply. This law has eliminated the monopoly of the Public Power Corporation S.A. (PPC) only in the non-interconnected islands. Moreover it has established the Regulatory Authority of Energy and the Hellenic Transmission System Operator S.A. The liberalization processes included the incorporation of a number of European directives and national legislation.

The latest important updates were – through the Law 4001/2011 – the establishment of the Operator of the Electricity Market, of the Independent Transmission Operator S.A. and of the Distribution System Operator S.A. Over the last decade a number of important investments have been made, through the construction of natural gas units and Renewable Energy Resources. Moreover, a significant number of participants have entered the relevant markets, acting either as suppliers of electricity to final customers or as traders of electricity in the interconnections.

During the last few years, there is a process in the EU towards the integration of European electricity and gas markets, through market coupling and the establishment of a common Target Model. The Greek electricity market, already acting as a transit country between cheap north borders and the more expensive Italian market, is considered a mature market and will play an important role for the integration of

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