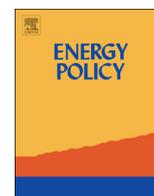




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# Energy consumption and economic growth in the light of meeting the targets of energy policy in the EU: The bootstrap panel Granger causality approach

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## HIGHLIGHTS

- Four groups of EU countries which meet energy policy targets at similar levels were identified.
- Energy-growth nexus depends on the level of compliance with energy policy targets.
- Most EU countries confirm the neutrality hypothesis.
- Countries which meet energy policy targets best confirm remaining hypothesis.

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## ABSTRACT

The aim of the paper is to assess linkages between energy consumption and economic growth in the light of compliance with the EU energy policy targets stated in the climate and energy package for 2020 in the European Union member states in the period 1993–2011. The study is divided into two main stages. During the first one, using cluster analysis methods, four groups of countries which met three energy policy targets stated in the package at similar levels were identified. During the second stage, the bootstrap Granger panel causality approach proposed by *Konya (2006)* was used to verify the hypothesis of causality between energy consumption and economic growth in the countries from four groups created in the previous step. The global financial crisis was also taken into account. The results obtained reveal that the level of compliance with energy policy targets influences linkages between energy consumption and economic growth. The results indicate causal relations in the group of countries with the greatest reduction of greenhouse gas emissions, the highest reduction of energy intensity and the highest share of renewable energy consumption in total energy consumption. In the remaining groups the results mostly confirm the neutrality hypothesis.

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## 1. Introduction

In March 2013 the European Commission adopted a Green Paper on a 2030 framework for climate and energy policies, which initiated a discussion on common climatic targets and the ways of meeting them<sup>2</sup>. The reference point for all discussions is the climate and energy

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<sup>2</sup> On 22 January 2014 the Commission proposed the framework for climate and energy policy after 2020 that is the 40% reduction in greenhouse gas emissions and 27% share of renewable energy in final gross consumption of energy for the European Union as a whole, without specifying separate national targets. The framework did not mention energy efficiency. The 40% reduction in greenhouse gas emissions in 2030 was stated in 'Energy Roadmap 2050' (*European Commission, 2011*).

package from 2008, which delineates the main targets for 2020 and specifies regulations helpful in meeting them. The strategic objectives of the EU policy (3 × 20) to be achieved by 2020 include: a 20% reduction in EU greenhouse gas emissions below the 1990 levels, raising the share of EU energy consumption produced from renewable resources to 20%, and a 20% improvement in the EU's energy efficiency.

In the context of the EU strategy, two important questions should be asked: first, is it possible and, if so, how to reconcile climate protection and economic competitiveness, and second, to what extent climate policy influences energy consumption and, consequently, competitiveness of European economy. These issues make the assessment of the impact of energy policy on the relations between energy consumption and economic growth an important research area in environmental economics.

Subject literature abounds in studies which deal with the relationship between energy consumption and economic growth

and various other parameters (e.g., Apergis and Payne, 2009a, 2009b, 2012; Narayan and Smyth, 2008; Narayan et al., 2010; Soytaş and Sari, 2003, 2009; Wolde-Rufael, 2009; Ozturk et al., 2010; Ozturk, 2010; Payne, 2010; Tsani, 2010; Menegaki, 2011; Pirlogea and Cicea, 2012; Costantini and Martini, 2010; Mumtaz et al., 2014; Zaman et al., 2011, 2012, 2013). They analyze various countries and use various modeling methods to verify four hypotheses regarding causal relations between energy consumption and economic growth: the growth hypothesis, the conservation hypothesis, the feedback hypothesis and the neutrality hypothesis. However, to the best of our knowledge, so far causality in the growth-energy nexus in the context of meeting the targets of energy policy in the EU has not been addressed in any of them.

The aim of the paper is to assess linkages between energy consumption and economic growth in the light of compliance with the EU energy policy targets stated in the climate and energy package for 2020 in the European Union member states in the period 1993–2011. Additionally, the level of compliance with those energy policy targets in the EU member states in the period 1993–2011 will be measured<sup>3</sup>.

The study was divided into two main stages. The aim of the first one was to identify the countries which met the targets of energy policy stated in the climate and energy package for 2020 at similar levels. Cluster analysis methods allowed for the objective identification of groups of such countries. During the second stage, a bootstrap Granger panel causality approach proposed by Konya (2006) was used to verify the hypothesis of causality between energy consumption and economic growth in the countries from the four groups obtained during the previous stage. It took into account commonly observed cross-sectional dependence in panel analysis for macroeconomic data and potential heterogeneity of growth and energy nexus in the analyzed countries. Homogeneity of the groups addressed the lump together problem. Since the analysis covers the period 2008–2009, the global financial crisis was also taken into account.

The paper contributes to the existing literature in several aspects.

Firstly, the analysis yielded homogeneous groups of countries with reference to three variables characteristic for energy policy stated in the climate and energy package for 2020. This allowed for the comparison of the countries with respect to the targets listed in this package including the results of the changes in the structure of energy production (a reduction of greenhouse gas emissions (GHG) and an increase of renewable energy in the gross final consumption of energy (RES)) as well as the modernization of economies (a reduction of energy intensity).

Secondly, the groups obtained in the previous stage were used to develop models for the countries which met the EU energy policy targets at similar levels, that is the countries with similar dynamics of energy consumption (including renewable energy sources) and the modernization of economy. In other studies countries were grouped according to their membership in international organizations or their level of economic development (e.g., the UE member states (Menegaki and Ozturk, 2013), OECD countries (Belke et al., 2011; Costantini and Martini, 2010), post-communist European countries (Papież and Śmiech, 2013), G7 member countries (Narayan and Smyth, 2008; Soytaş and Sari, 2006), or BRIC (Pao and Tsai, 2010)). Another criterion was the geographic location (e.g., African countries (Eggoh et al., 2011), Central American countries (Apergis and Payne, 2009a), South American countries (Apergis and Payne, 2010), MENA (Ozturk and Acaravci, 2011), SAARC (Mudakkar et al., 2013), CIS (Apergis and Payne, 2009b), Narayan and Popp (2012) analyzed 93 countries according to their geographical location). Khan et al. (2014) took into account both

the economic development and the geographical location and investigated countries not belonging to OECD with low income, middle income and high income, OECD countries with high income, as well as countries from South Africa, the Middle East and North Africa. Such criteria were not always conducive to creating groups of homogeneous countries with reference to the relations between energy and growth nexus. If the elements of the panel are not homogeneous, 'traditional' panel models may give erroneous results of causality tests (see Wilson and Butler, 2007).

Thirdly, the method applied, that is the bootstrap panel causality approach proposed by Konya (2006), yielded the results that are robust to cross-sectional dependence and slope heterogeneity and do not suffer from the small-sample problem, since causality tests are based on country-specific bootstrap critical values. Additionally, this method allows for inference on dependencies in particular countries, which gives a more detailed picture than a traditional panel approach.

Finally, the comparison of causal relations with the levels at which energy policy targets stated in the climate and energy package for 2020 were met revealed the conditions in which a significant relationship between energy consumption and economic growth was observed.

Additionally, the analysis took into account the global financial crisis, which considerably influenced the relations between energy consumption and economic growth.

The paper consists of the following sections. Section 2 presents the most important findings of studies investigating the growth and energy nexus in the European Union member states. Empirical methodology that allows for the appropriate treatment of cross-sectional dependence and slope heterogeneity in panel data analysis is presented in Section 3. Section 4 describes the data, and Section 5 reports and comments on the empirical results. The paper ends with the conclusions and policy implications.

## 2. Review of the results for European Union countries

The existing literature offers a wide range of perspectives and insights into the issue of the growth – energy nexus, which, however, sometimes report contradicting results. They can be divided into country-specific case studies and multi-country studies (Karanfil, 2009). Various econometric methods, various periods of analysis, and various control variables can be found in all of them.

Taking into consideration the methodological perspective, four generations of contributions were identified (Belke et al., 2011; Costantini and Martini, 2010). The first-generation studies were based on VAR methodology (Kraft and Kraft, 1978) and assumed that the time series were stationary. The second-generation studies accounted for non-stationarity and applied Engle-Granger (1987) two-step procedure to test pairs of variables for cointegrating relationships. The third-generation studies used multivariate estimators (Johansen, 1991). This approach allowed for more than two variables in cointegration relationship and analyzed causality both in the short- and long-run simultaneously. The fourth-generation studies were based on panel methods testing for unit roots, cointegration and Granger causality. Using panel cointegration has several advantages. It allows for higher degrees of freedom, reduces multicollinearity between regressors, and improves the power of the cointegration test, especially for annual data. The main disadvantage of this approach is the need to assume cross-sectional independence, which is difficult to satisfy in a panel data. What is more, in traditional panel models different countries are treated as an entity. As a result, it is impossible to identify the difference in the dynamic relationship between energy consumption and economy (slope homogeneity).

Table 1 presents an overview of studies on energy consumption and economic growth in European countries published in recent years. Despite their substantial number, not all European countries

<sup>3</sup> The choice of this period of analysis was dictated by our wish to include the relations in countries of Eastern Europe, which witnessed rapid political and economic changes in the 1990s.

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