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Electricity consumption and economic growth: Exploring panel-specific differences

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HIGHLIGHTS

- The causal relationship between electricity consumption and GDP is investigated.
- Cointegration techniques are used for 160 countries and 13 subsamples.
- Urbanization and electricity trade are accounted for as additional covariates.
- Causal inferences are found to be associated with panel-specific differences.
- Policy issues are discussed based on the study results.

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ABSTRACT

In this paper, we examine the long- and short-run dynamics between electricity consumption and economic activities, using panel data of per capita electricity consumption and per capita GDP of 160 countries for the period of 1980–2010, accounting for the degree of electricity dependence and the level of urbanization. Furthermore, in order to capture the differences in this relationship, the full sample is divided into various subsamples based on countries' income levels, regional locations and OECD memberships. This framework is argued and found to be appropriate since the causal links and inferences arising therefrom differ considerably among the subsamples, which led us to conclude that the electricity-growth nexus is highly sensitive to regional differences, countries' income levels, urbanization rates and supply risks.

1. Introduction

As one of the major components of energy consumption, the importance of electricity to economic growth has been recognized not only by economists, but also by businessmen, engineering, energy and government agencies. As stated by the US Energy Information Administration (EIA): "a country's economy and its energy use, particularly electricity use, are linked. Short-term changes in electricity use are often positively correlated with changes in economic output" (EIA, 2013b).[1]

Generally speaking, the relationship between electricity consumption and economic growth can be categorized into four testable causal hypotheses: (1) growth hypothesis assumes that electricity is a necessary factor of economic growth, implying thus a causality running from electricity to economic growth; (2) conservation hypothesis postulates a causality running from economic growth to electricity consumption; (3) feedback hypothesis emphasizes the interdependence between electricity consumption and economic growth; (4) neutrality hypothesis assumes no causal link. In order to make proper policy suggestions, it is necessary and essential to clarify the relationship and the direction of causality between them.

The purpose of the present paper is to complement and extend the previous literature that has investigated the causal relationship between economic growth and electricity consumption, which has so far provided conflicting results. To do so, we add

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[1] EIA showed that the US electricity use and economic growth are linked as suggested by data over the past 60 years. The projection through 2040 also shows that this relationship is about to change in the US. See for more details (EIA, 2013b).

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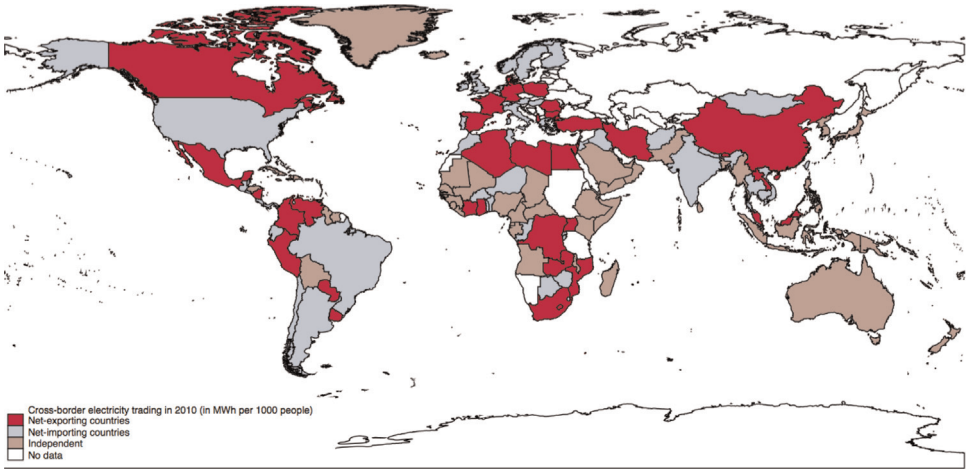

Fig. 1. Net electricity import across countries. Data sources: Authors' calculations based on (UNCTAD, 2013) and (EIA, 2013a).

cross-sectional dimension to increase the power of various tests in a multivariate framework, which addresses the problem of omitted variable bias and accounts for different characteristics across countries. More specifically, using panel data of per capita electricity consumption and per capita real Gross Domestic Product (GDP) for 160 countries[2], the paper examines both the long- and short-run dynamics between electricity consumption and economic activities, taking into account both the degree of electricity dependence and the level of urbanization. Furthermore, in order to capture the differences in this relationship, the full sample is divided into: (1) four subsamples based on countries' income levels, (2) seven subsamples based on regional locations, and (3) two subsamples according to the identity of the OECD memberships.

The main contribution of this study is at least twofold. First, it attempts to determine the relationship between electricity consumption, economic growth, electricity dependence and urbanization in more detail and in a much broader geographic context compared to all previous studies. The 160 countries included in this paper represent 96.52% of global GDP[3] and 94.61% of global electricity consumption[4] in 2010. While the correlation between electricity consumption and economic growth has been confirmed by many scholars, it is not homogeneous for all countries. Through correlation analyses for more than 100 countries Ferguson et al. (2000) suggest that this relationship is stronger in wealthy countries and that the link with wealth creation would be more appropriately attributed to electricity consumption rather than energy use in general. Moreover, Yoo and Kwak (2010) show that electricity consumption-GDP nexus may have different forms depending on countries' income levels. Therefore, we choose to study electricity consumption-GDP nexus and conduct successively subsample studies by using three different criterions, which account for income, organizational and geographic differences across panels. Although this relationship seems to be of a long-term rather than short-term nature, from economic and energy policy viewpoints studies in this field should integrate both short- and long-term perspectives. In the framework of the present study, the existence of a long-run causality indicates that the equilibrium between the variables involved in the analysis determines the level of electricity consumption while a short-run causality signifies that some of these variables may have a delayed impact on electricity consumption that responds only to the short-term shocks. In other words, in the case of long-run relationship, movements along the equilibrium path are permanent whereas the interactions should be considered transitory in the case of short-run causality (or long-run non-causality). Thus, different policy implications emerge depending upon whether causality runs in the short and/or long run.

Second, we use a multivariate framework, which allows us to go beyond a simple GDP-electricity nexus. In addition to electricity consumption and GDP, we incorporate net import of electricity and urbanization. The reason for including these two variables in the framework of this study is straightforward. First, net import of electricity captures to what extent a given country is dependent on imported electricity. As indicated by Gnansounou (2008) the net import of electricity is one of the three sub-dimensions of the electricity dependency or supply vulnerability (the non-diversification of electricity generation and the risk of non-acceptance by the public of a dominated technology of electricity generation are cited to be the other two dimensions). Being a negative externality, energy supply risks constitute the policy issue of security of supply. Therefore the supply risks are addressed by striving to “bring production home”, which is an equal term as energy dependency (OECD, 2010). It is clear that high dependency may render the economy highly vulnerable to external shocks, and in this perspective, it may have an effect on the dynamic relationship between electricity consumption and income in the short run as well as the long run. Fig. 1 is a visualization of the data of electricity net import or export in 2010.[5] It shows that one electricity-export country is generally surrounded by electricity-import countries and vice versa.[6] Electricity trade is generally localized within region. Due to high costs of storage and physical transmission

[2] To be more specific, independent territories and special administrative regions are treated separately. For example, Hong Kong is separated from China mainland for estimation. Independent territories like Netherlands Antilles and French Polynesia are considered as different countries from Netherlands and France. A complete country list with the indications of their geographic locations, income levels and the status of the OECD membership can be found in Table A1 in Appendix A.

[3] Sourced from the United Nations' database *UNCTAD*, the total GDP in 2010 is 51,263,609 million US dollars at 2005 constant prices and 2005 constant exchange rates. We calculate the percentage of the total GDP of sample countries in global GDP in 2010.

[4] The total electricity consumption in 2010, namely 17,780 billion kilowatt hour, is given by website Indexmundi (2013) sourced from *CIA World Factbook*. Other sources may provide information on total global electricity consumption with slight differences.

[5] Negative values on net electricity import signify countries being net-exporters.

[6] As seen on the maps, the data of Russia and former member countries of the Soviet Union are excluded with caution due to the dissolution of the Soviet Union at the beginning of 90s. It is not appropriate to distribute these data before the 90s into 15 independent post-Soviet states. Accurate data do not exist even in the articles and reports written in Russian (Jobert et al., 2014).

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