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Energy consumption and economic growth relationship: Evidence from panel data for low and middle income countries

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ABSTRACT

This paper uses the panel data of energy consumption (EC) and economic growth (GDP) for 51 countries from 1971 to 2005. These countries are divided into three groups: low income group, lower middle income group and upper middle income group countries. Firstly, a relationship between energy consumption and economic growth is investigated by employing Pedroni (1999) panel cointegration method. Secondly, panel causality test is applied to investigate the way of causality between the energy consumption and economic growth. Finally, we test whether there is a strong or weak relationship between these variables by using Pedroni (2001) method. The empirical results of this study are as follows: i) Energy consumption and GDP are cointegrated for all three income group countries. ii) The panel causality test results reveal that there is long-run Granger causality running from GDP to EC for low income countries and there is bidirectional causality between EC and GDP for middle income countries. iii) The estimated cointegration factor, β, is not close to 1. In other words, no strong relation is found between energy consumption and economic growth for all income groups considered in this study. The findings of this study have important policy implications and it shows that this issue still deserves further attention in future research.

1. Introduction

The topic of causal relationship between energy consumption and economic growth has been well-studied in the energy economics literature for both developing and developed countries. The empirical outcomes of these studies have been varied and sometimes found to be conflicting due to the different time periods, different variables used, countries studied and different econometric methodologies used.

The causality relationship between energy consumption and economic growth has important policy implications. Hence, several studies have attempted to establish the relationship between energy consumption and economic growth (See Table 1). A general observation from these studies is that the results have been mixed. From Table 1 it can be concluded that, almost all types of causality results have been reported in the literature (See Ozturk, 2010; for detailed literature survey on energy–growth nexus).

According to the results of the mentioned studies in Table 1 and in energy literature, it is not possible to conclude definitely the direction of causality between energy consumption and economic growth. However, it is known that this causality is of major importance for effective energy policy design and implementation. A country that is energy dependent (a country in which causality runs from energy consumption to growth) will have a cautious energy policy because any negative shock on energy supply will have negative effects on economic growth. On the other hand, in an economy where energy consumption is determined by economic growth (a country in which the direction of causality runs from economic growth to energy consumption) an energy conservation policy will have very little affect on economic growth (Ouedraogo and Diarra, 2010).

The present study may be considered as a complementary study to the previous studies about energy consumption–economic growth relationship. Different from previous studies, this study not only re-examine the weak relation between energy consumption and growth, but also examine the strong relation by using time series and panel data techniques. In addition to investigate weak or strong relation, panel causality test is applied to examine the relations between energy consumption and economic growth. Another contribution of this paper is to partially resolve the "lump-together" problem in using panel data; we classify the panel data into three sub-panels based on the difference in income levels before further estimation. Thus, this study extends the empirical literature on the causal relationship

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Table 1
Summary of empirical studies on energy consumption–growth nexus.

Authors	Period	Country	Methodology	Causality relationship
Masih and Masih (1996)	1955–1990	6 Asian countries	Cointegration, Error correction model	EC→GDP (India) GDP→EC (Indonesia, Pakistan) GDP–EC (Malaysia, Philippines, Singapore)
Asafu-Adjaye (2000)	1971–1995 1973–1995	India, Indonesia (1973–95) Philippine, Thailand (1971–95)	Cointegration and Granger causality based on ECM	EC↔GDP (Philippine, Thailand) EC→GDP (India, Indonesia)
Wolde-Rufael (2005)	1971–2001	19 African countries	Toda Yamamoto's Granger causality	GDP→EC (Algeria, Congo DR, Egypt, Ghana, Ivory Coast) EC→GDP (Cameroon, Morocco, Nigeria) EC↔GDP (Gabon, Zambia) GDP–EC (Benin, Congo RP, Kenya, Senegal, South Africa, Sudan, Togo, Tunisia, Zimbabwe)
Lee (2006)	1960–2001	11 developed countries	Granger causality test	Mixed results
Al-Iriani (2006)	1970–2002	6 countries of GCC	Panel cointegration, GMM	GDP→EC
Mehrara (2007)	1971–2002	11 Oil Exporting countries	Panel cointegration	GDP→EC
Lee and Chang (2007)	1965–2002 1971–2002	22 Developed countries,18 Developing Countries	Panel VARs and GMM	GDP→EC (Developing countries) EC↔GDP (Developed countries)
Akinlo (2008)	1980–2003	11 countries in sub-Saharan Africa	ARDL bounds test	Mixed results
Chiou-Wei et al. (2008)	1954–2006	Asian countries and USA	Granger causality	GDP–EC (USA, Thailand, South Korea) GDP→EC (Philippines, Singapore) EC→GDP (Taiwan, Hong Kong, Malaysia, Indonesia)
Lee et al. (2008)	1960–2001	22 OECD countries	Panel cointegration, Panel VEC model	EC↔GDP
Huang et al. (2008)	1972–2002	82 Low, middle and high income countries	Panel VAR, GMM model	GDP→EC (Middle and high income countries) GDP–EC (Low income countries)
Narayan and Smyth (2008)	1972–2002	G-7 countries	Panel cointegration, Granger causality	EC→GDP
Lee and Chang (2008)	1971–2002	16 Asian countries	Panel cointegration and Panel ECM	EC→GDP (in the long run) GDP–EC (in the short run)
Apergis and Payne (2009)	1980–2004	6 Central American countries	Pedroni Panel cointegration, error correction model	EC→GDP

Note: EC→GDP means that the causality runs from energy consumption to growth.
GDP→EC means that the causality runs from growth to energy consumption.
EC↔GDP means that bidirectional causality exists between energy consumption and growth.
EC–GDP means that no causality exists between energy consumption and growth. EC=energy consumption, VAR=vector autoregressive model, ECM=error correction model, ARDL=autoregressive distributed lag, EC=energy consumption, GDP=real gross domestic product, VEC= vector error correction model and GMM=generalized method of moments.

between energy consumption and economic growth in the case of low income, lower middle income and upper middle income countries. The results obtained in this study are dependent on the sample period, the variables used and the methodology employed.

The objective of this paper is to investigate the relationship and causality between energy consumption and economic growth in 51 countries for the 1971–2005 period by using Pedroni (1999, 2001) panel cointegration and panel causality method. The rest of the paper is organized as follows: the next section describes the data and methodology. Section. 3 presents the results from empirical analysis. Section. 4 concludes the paper.

2. Data and methodology

We use annual energy consumption, EC hereafter and GDP per capita data in this study. EC is kg of oil equivalent per capita and GDP per capita data with constant 2000 US$. The data are sourced from World Bank (2008). 51 countries are considered in this study are selected according to data availability for the 1971–2005 period. All variables are employed with their natural logarithms form to reduce heteroscedasticity. This study examined these countries under three income groups. According to the World Bank country classification, these 51 countries are classified as low income countries (Bangladesh, Benin, Congo, Ghana, Haiti, India, Kenya, Nepal, Nigeria, Pakistan, Sudan, Togo, Zambia and Zimbabwe), lower middle income countries (Algeria, Bolivia, Cameroon, China, Colombia, Congo, Rep., Dominican Republic, Ecuador, Egypt, El Salvador, Guatemala, Honduras, Indonesia, Iran Islamic Rep., Jamaica, Morocco, Nicaragua, Paraguay, Peru, Philippines, Sri Lanka, Syrian Arab Republic, Thailand and Tunisia) and upper middle income countries (Argentina, Chile, Costa Rica, Gabon, Hungary, Malaysia, Mexico, Oman, Panama, South Africa, Turkey, Uruguay and Venezuela). Table 2 provides the descriptive statistics of these two series for all three income group countries.

To investigate the relationship and causality issue, panel unit root analysis, panel cointegration analysis, panel causality analysis, panel fully modified ordinary least square (FMOLS) and panel dynamic ordinary least square (DOL) estimates are employed in this study.

3. Empirical results

3.1. Panel unit root analysis

Cointegration analysis developed in the mid-80s introduced the idea that even if underlying time series are non-stationary, linear combinations of these series might be stationary. Therefore,