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Energy consumption and economic growth in the next 11 countries: The bootstrapped autoregressive metric causality approach

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ABSTRACT

Departing from previous literature, using bootstrapped autoregressive metric causality approach which is more robust against non-stationarity and break problems than lag augmented tests, this study analyzes causal relation between economic growth and energy consumption in the Next 11 countries. Estimating a trivariate model consisting of GDP per capita, energy consumption per capita and gross capital formation, it was found that the neutrality hypothesis is valid for all of the countries except for Turkey. These findings imply that energy conservation-oriented policies should be implemented in Bangladesh, Egypt, Indonesia, Iran, Korea, Mexico, Pakistan and Philippines. In the case of Turkey, a unidirectional causal nexus was found from energy consumption to economic growth. Since the growth hypothesis is valid, energy conservation policy poses an obstacle for economic growth in Turkey.

1. Introduction

Energy consumption has been closely connected with the economic growth since energy is an indispensable input in aggregated production function. So it is widely believed that there is a close relation between energy policy and economic growth. However, the potential of change in energy-growth nexus can affect the optimal energy policy in a country. The saving of energy in industrial, agricultural, services and housing sectors may be a necessity, if it helps to decrease energy bills, cost and price of goods and services and greenhouse gas emission. Furthermore, energy saving policy can lead to better resource allocation by shifting the capital and labor from energy sector to more productive ones. However, if production of a country depends heavily on energy, energy conservation measures may put a constraint on economic growth. Therefore, policy makers need to know the causal relation between economic growth and energy consumption.

The causal relation between energy consumption and economic growth has been embodied in four hypotheses (Ozturk, 2010; Payne, 2010a, 2010b). The growth hypothesis signifies that energy consumption has an important part in the economic growth process directly and/or as a complement to capital and labor (Apergis and Payne, 2009). If unidirectional causal nexus is found from energy consumption to economic growth, the growth hypothesis is endorsed. In this scenario, energy dependence of the related country's economic performance is so high that shocks to energy supply will have a negative impact on the economic growth. In the case of the growth hypothesis, energy saving-oriented policies may have a detrimental impact on economic growth. In the scenario of growth hypothesis, even as a complementarity relation between energy and capital was assumed, in the long run the effect of technological advances on energy efficiency may be so big that it leads to a decrease in energy dependency of production process at the expanse of an increase in capital usage. If one allows the substitution of capital instead of energy, the causal relation from economic growth to energy consumption may appear. Especially if energy price is high, the effort for improving energy efficiency and substitution between energy and capital input can increase. I""n the mechanism of this process, firstly, high economic growth

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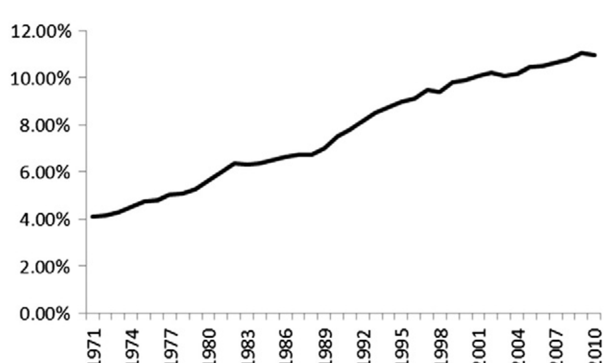
may lead to an increase in energy demand and energy price. Secondly rise of energy price leads to a pressure on technological progress which has the rebound effect. Since the rise of energy supply and energy-efficiency improvements may lead to reduction of the marginal cost of energy services, it may lead to a decrease in energy price (Sorrell, 2009). If a long standing increase of energy supply has been more than energy demand which ensures maximum energy efficiency, the price of energy may substantially decrease. Lastly, decrease in energy price may lead to an increase in energy consumption. In this direction *the conservation hypothesis* denotes that economic growth is the dynamic which causes the consumption of energy sources. The validity of the conservation hypothesis is verified if there is uni-directional causality from economic growth to energy consumption. In this scenario, since there is excessive energy consumption, energy saving policies will not have a negative impact on economic growth.

The feedback hypothesis implies a bidirectional causal relation between energy consumption and economic growth. In this situation, an increase (a decrease) in energy consumption causes an increase (a decrease) in real GDP, and an increase (a decrease) in real GDP leads to an increase (a decrease) in energy consumption. If energy input has an insignificant portion in production function, causal nexus between energy consumption and economic growth nexus may disappear. *The neutrality hypothesis* argues that energy consumption does not affect economic growth and vice versa. The absence of causal nexus between energy consumption and economic growth provides evidence for the validity of the neutrality hypothesis. In this scenario, energy conservation policies devoted to reducing energy consumption will not have an influence on economic growth.

Departing from previous papers in the literature, this study concentrates on three issues. Firstly, a multivariate model is employed in the case of Next-11 (hereafter N-11) countries which were neglected in the empirical literature. Although N-11 countries are unlikely to rival the BRICs in scale, their energy consumption has been rapidly increased. As seen in Graph 1, even as the share of global energy consumption of N-11 countries is about 4% in 1971, the ratio has reached to 11% in 2010.

Furthermore, according to Goldman Sachs projection, N-11 aggregate GDP could reach two-thirds the size of the G7 by 2050 (Goldman Sachs, 2007). Therefore one can expect that the contribution of N-11 countries to global economic and political developments has been increasingly important. Second, to the best of our knowledge, this is the first study which applies Granger causality test using autoregressive moving average models (ARMA) in the case of energy-growth nexus. The causality test based on the AR metric approach has two advantages. The first advantage of this method is that it can be carried out irrespective of whether the variables involved are stationary or not and regardless of the existence of a cointegration relation among them. Second, using Monte Carlo simulation, Di Iorio and Triacca (2013) indicate that if there is a break in variance, the AR metric causality approach seems superior to the lag-augmented Wald tests such as Toda–Yamamoto (hereafter T–Y) procedure. The last issue in this paper is the problem of a small sample since the standard asymptotic distribution theory may often cause significant over-rejection in the case of a small sample (Hacker and Hatemi-J, 2006; Lach, 2010). Following Di Iorio and Triacca (2013) and Lach (2010), the bootstrap procedure was applied to achieve robust critical values. These substantive aspects will contribute to develop clearer inferences for policy makers.



Graph 1. N-11 countries' share of global energy consumption.

The rest of the paper is organized as follows: The next section describes the model and data. In Section 3 the method and findings from empirical analysis are presented. Section 4 presents conclusion and policy implications of the analyses.

2. Literature review

Some studies in the energy-growth literature focused separately on N-11 countries. Table 1 summarizes the studies in the literature. The analyses about N-11 countries do not incorporate all of the N-11 countries. Especially there are too few studies in the case of Bangladesh, Egypt, Iran and Mexico in the literature. In addition to the standard Granger causality test, the Toda and Yamamoto (1995) procedure, Hsiao's version of Granger causality, vector error correction model, and autoregressive distributed lag model and cointegration test are highly applied to ascertain causal relations between economic growth and energy consumption. Although the methods which are robust to unit root problem are generally used in the literature, most of them do not take into account a structural break. However most of the time series data have both non-stationary and structural break properties especially in the pattern of developing countries. A structural break may lead to bias results in unit root and causality tests.

As it can be seen in Table 1, even as the relation between energy consumption and income in the case of N-11 countries has been separately analyzed in some studies, the empirical results have not illustrated a consensus.

Table 2 demonstrates that there is no consensus on energy-growth relation in the case of N-11 countries. For example in the case of Turkey, while three studies find a unidirectional causal relation from energy consumption to economic growth, four papers reach a one-way causal nexus from economic growth to energy consumption. In addition, three studies find bidirectional causal relation and seven studies conclude that there is no causal relation between energy consumption and economic growth.

3. Model and data

Following the Solow growth model, a trivariate model was estimated in this study. Although, economic growth is affected by labor, capital and technology in aggregated growth model, technology is an exogenous variable. Since omitted variables in the aggregated growth model may lead to a bias in findings, gross capital formation was added to the estimated model. However, labor could not be among variables in the model, due to the insufficient observation number. The estimated VAR model is represented in Eqs. (1), (2) and (3).

$$y_t = a_{10} + a_{11}y_{t-1} + a_{12}e_{t-1} + a_{13}c_{t-1} + \varepsilon_{yt} \quad (1)$$

$$e_t = a_{20} + a_{21}y_{t-1} + a_{22}e_{t-1} + a_{23}c_{t-1} + \varepsilon_{et} \quad (2)$$

$$c_t = a_{30} + a_{31}y_{t-1} + a_{32}e_{t-1} + a_{33}c_{t-1} + \varepsilon_{ct} \quad (3)$$

where *y*, *e* and *c* are real GDP per capita, energy use per capita (kg of oil equivalent) and gross capital formation, respectively. All variables are