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Dynamics of electricity consumption, oil price and economic growth: Global perspective

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ABSTRACT

This study uses the data from 157 countries from 1960 to 2014 to analyze the relationship between economic growth, electricity consumption, oil prices, capital, and labor. The economic growth of developing countries with industrial infrastructure has a more significant association with electricity consumption than oil prices. We use oil prices and electricity consumption jointly to study highly predictive observations for economic growth. The data are categorized by income, OECD and regional levels. The panel cointegration, long-run parameter estimation, and Pool Mean Group tests are used to analyze the cointegration and short-run and long-run relationships between the variables. The empirical results indicate the presence of cointegration between the variables. The presence of feedback effects between electricity consumption and economic growth, oil prices and economic growth is valid. These findings confirm that in spite of the oil prices, developing countries rely heavily on electricity consumption for economic growth. In the short run, growth and feedback effects suggest that more vigorous electricity policies should be implemented to attain sustainable economic growth for the long-term.

1. Introduction

The economic progress of developing countries relies heavily on electricity. The production of manufacturing industries declines due to electricity shortages, which, in turn, destabilize an economy. Electricity consumption is a key component of economic growth and is directly or indirectly a complement to labor and capital as a factor of production (Costantini and Martini, 2010). Various studies have revealed the diverse impact of electricity consumption on economic growth (Yuan et al., 2007, 2008; Chen et al., 2007; Narayan and Prasad, 2008; Abosedra et al., 2009; Mutascu, 2016a, 2016b; Ahmed and Azam, 2016; Streimikiene and Kasperowicz, 2016). For example, some studies suggest a positive impact of electricity consumption on economic growth (Shiu and Lam, 2004; Yuan et al., 2007; Shahbaz and Lean, 2012; Iyke, 2015; Tang et al., 2016; Streimikiene and Kasperowicz, 2016). Ozturk (2010) argues that if economic growth is inversely affected by energy consumption, then different arguments could justify the adverse impacts of energy consumption on economic growth. For example, we could imagine a situation in which a growing economy aims to reduce the level of energy consumption through production shifts to less energy-intensive sectors. Furthermore, the inefficient use of energy, such as constraints in capacity use or an inefficient supply of energy, may also have a negative impact on economic growth or growth in real GDP (Chontanawat et al., 2008; Payne, 2010; Ozturk, 2010). A large number of developing countries have concerns about electricity shortages due to scarce resources and infrastructure (Allcott et al., 2014; Shahbaz and Ali, 2016). The relationship between electricity consumption and economic growth also varies across the income levels of countries (Yoo and Kwak, 2010). Similarly, Ferguson et al. (2000) reported that the relationship between electricity consumption and economic growth is stronger in high-income countries.

Oil prices are a key component of energy, and their importance in economic development has been recognized by economists, policy makers, businessmen, households, and researchers. After the 1973 oil crisis, several studies (Timilsina, 2015; Kilian and Vigfusson, 2011; Kilian, 2008; Hamilton, 1983, 1985; Gisser and Goodwin, 1986; Mork, 1989) affirmed an inverse relationship between oil prices and economic growth. Economists and researchers have reached a consensus that oil price volatility simultaneously reduces economic growth. However, the recent literature shows the negative relationship decreasing over time because of oil alternatives and preemptive governmental measures against sudden oil price shocks (Doroodian and Boyd, 2003; Jbir and Zouari-Ghorbel, 2009). Oil-importing developing economies are severely affected by oil price hikes because of a lower tax share on oil

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prices. Moreover, developed economies have a higher tax share on oil. Therefore, such oil price shocks may be mitigated to an extent by suspending the tax share as oil prices rise. Developing countries with less of a tax share on oil have less ability to absorb oil price shocks. Consequently, oil price hikes appear to have a more adverse impact on developing economies.

These dynamics between electricity consumption, oil prices and economic growth prompt researchers to conduct empirical research and provide diverse empirical evidence. This paper is a humble effort to provide comprehensive empirical evidence by covering data from 157 countries for the period from 1960 to 2014. This study contributes to the existing energy literature in four ways: (i) The study employs the growth model developed by Solow (1956) by augmenting the production function to investigate the role of electricity consumption and oil prices on domestic production. The industrial infrastructure heavily relies on oil as an input to production operations and transportation. The increase in oil prices leads to higher costs of production and drives inflation, which adversely affects investment and purchasing power. Electricity supply is the basic element of industrial production, and countries facing an electricity shortage cannot sustain the pace of economic growth. The economic growth of developing countries with industrial infrastructure has a high and significant association with electricity consumption compared to oil prices. The production process can be slowed due to an electricity shortage (Shahbaz and Ali, 2016). Such a decline in output has a direct influence on financial values. On the other hand, to mitigate such massive losses, many firms attempt to acquire alternative energy-producing plants, which also escalate production costs. The increase in electricity consumption in manufacturing economies may help to trigger economic growth (Kahane and Squitieri, 1987). Therefore, this study has incorporated electricity consumption as a factor of domestic production along with oil prices in an augmented production function. The joint use of electricity consumption and oil prices in the augmented production function will also provide new guidelines for policy makers to design comprehensive growth policies while considering the role of electricity consumption and oil prices. The ignorance of relevant variables in the function of production may be a reason for the ambiguous results of previous studies in the existing literature (Shahbaz et al., 2016). (ii) The paper investigates the electricity-growth nexus using data from 157 countries, which are further categorized into sub-panels, such as regional, income, OECD and non-OECD levels, to mitigate heterogeneity in the data. (iii) This study applies the panel cointegration approach developed by Westerlund (2007). The Fully Modified Ordinary Least Square (FMOLS) and Pool Mean Group (PMG) tests have also been applied to scrutinize the short-run and long-run associations between the variables. (iv) The heterogeneous panel causality test originated by Dumitrescu and Hurlin (2012) is used to examine the causality relationship between electricity consumption and economic growth in heterogeneous panels. Our results show the existence of a feedback effect between electricity consumption and economic growth. The association between oil prices and economic growth is also bidirectional. Gross fixed capital formation and labor lead to economic growth. The findings show heavy reliance by developing countries on electricity consumption rather than oil prices for sustainable economic growth. This finding varies across income levels and regions.

The rest of the study is organized as follows: Section 2 provides a brief literature review of energy consumption, electricity consumption, oil prices and Pedroni panel cointegration. Section 3 discusses the data and methodology used for estimations. Section 4 reports the results and conclusion. Section 5 provides concluding remarks.

2. Literature review

We have divided the literature review into two portions: the (i) electricity consumption-economic growth nexus and (ii) oil price-economic growth nexus.

2.1. Electricity consumption and economic growth[1]

Researchers and academics have researched the energy-growth nexus using time series and panel data sets but have reported conflicting empirical findings (Ozturk, 2010). These discrepancies may not help policy makers in designing comprehensive economic and energy policies to use electricity consumption as an economic tool to sustain economic growth in the long run (Payne, 2010).[2] For example, Murray and Nan (1996) applied the causality test developed by Granger (1969) to examine the relationship between electricity consumption and economic growth using data from 15 countries from 1970 to 1990. They found neutral effects between both variables in the cases of India, the Philippines, and Zambia. Furthermore, their analysis indicates that the conservation hypothesis is valid for Colombia, El Salvador, Indonesia, and Kenya, whereas the growth effect is found in Mexico, Canada, Hong Kong, Pakistan, Singapore, Turkey, Malaysia, and South Korea. Wolde-Rufael (2006) applied the bounds testing approach developed by Pesaran et al. (2001) as well as the causality developed by Toda and Yamamoto (1995) to examine cointegration and causality between electricity consumption and economic growth in 17 African countries. The results reveal that economic growth causes electricity consumption in 6 countries (Cameroon, Ghana, Nigeria, Senegal, Zambia, Zimbabwe), whereas electricity consumption causes economic growth in 3 countries (Benin, Republic of Congo, Tunisia), and the feedback effect exists between both variables in 3 countries (Egypt, Gabon, Morocco).[3] Yoo (2006) investigated the direction of the causal association between electricity consumption and economic growth for ASEAN countries and reported a feedback effect for Malaysia and Singapore and that economic growth causes electricity consumption in Indonesia and Thailand. In the case of the OPEC region, Squalli (2007) employed the bounds testing and causality approaches developed by Pesaran et al. (2001) and Toda and Yamamoto (1995), respectively, to examine cointegration and causality between electricity consumption and economic growth. The causality results indicate the dependence of economic growth on electricity consumption. Chen et al. (2007) investigated the association between electricity consumption and economic growth in 10 industrialized countries from 1971 to 2001. Their analysis showed that electricity

[1] A summary of electricity consumption-economic growth is given in Table A1 (see Appendix A).

[2] The existing literature on electricity consumption and the economic growth relationship provides four conflicting hypotheses: (i) The feedback effect reveals that electricity consumption causes economic growth and that economic growth causes electricity consumption. This hypothesis is empirically validated by Masih and Masih (1996a, 1996b), Constantini and Martini (2010), Shahbaz et al. (2012), Polemis and Dagoumas (2013), Mutascu (2016a, 2016b) and Sarwar et al. (2017). The feedback effect indicates that a decline in the electricity supply impedes economic growth and a reduction in economic growth will decrease electricity demand (ii) The growth hypothesis validates the presence of unidirectional causality running from electricity consumption to economic growth. This indicates that electricity consumption plays a vital role in enhancing domestic production and, hence, economic growth. Empirically, the growth hypothesis is empirically confirmed by Murry and Nan (1994), Khan et al. (2007), Pradhan (2010), Das et al. (2012), Tang and Shahbaz (2013), Wolde-Rufael (2014), Iyke (2015) and He et al. (2017). The feedback and growth hypothesis reveals the importance of energy- (electricity) exploring policies to attain long-run economic growth. (iii) The conservation hypothesis reveals that unidirectional causality runs from economic growth to electricity consumption. This shows that electricity consumption does not play a vital role in stimulating economic growth. The conservation hypothesis is empirically validated by Cheng and Lai (1997), Aqeel and Butt (2001), Narayana and Singh (2007), Narayan et al. (2010), Mahmoodi and Mahmoodi (2011), Shahbaz and Feridun (2012) and Kasman and Duman (2015). (iv) The neutral effect indicates that electricity consumption does not lead economic growth and vice versa. This hypothesis is empirically confirmed by Yu and Hwang (1984), Chontanawat et al. (2008), Wolde-Rufael (2009) and Smiech and Papiez (2014). The conservation and neutral hypotheses reveal minor (or no) role of electricity consumption in promoting economic growth. In such circumstances, energy (electricity) conservation policies are suitable because they have no adverse effect on economic growth.

[3] A neutral effect also exists in the cases of Algeria, PR Congo, Kenya, South Africa, and Sudan.