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# The nexus of electricity consumption, economic growth and $CO_2$ emissions in the BRICS countries

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## HIGHLIGHTS

- We examine the nexus of electricity, GDP growth and $CO_2$ emissions in BRICS.
- We take into account cross-sectional dependency and heterogeneity across countries.
- Electricity–GDP: Feedback for Russia and conservation for South Africa.
- $CO_2$–GDP feedback for Russia, from GDP to $CO_2$ in SA, $CO_2$ to GDP in Brazil.
- Only from electricity consumption to emissions for India.

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## ABSTRACT

This study reexamines the causal link between electricity consumption, economic growth and $CO_2$ emissions in the BRICS countries (i.e., Brazil, Russia, India, China, and South Africa) for the period 1990–2010, using panel causality analysis, accounting for dependency and heterogeneity across countries. Regarding the electricity–GDP nexus, the empirical results support evidence on the feedback hypothesis for Russia and the conservation hypothesis for South Africa. However, a neutrality hypothesis holds for Brazil, India and China, indicating neither electricity consumption nor economic growth is sensitive to each other in these three countries. Regarding the GDP–$CO_2$ emissions nexus, a feedback hypothesis for Russia, a one-way Granger causality running from GDP to $CO_2$ emissions in South Africa and reverse relationship from $CO_2$ emissions to GDP in Brazil is found. There is no evidence of Granger causality between GDP and $CO_2$ emissions in India and China. Furthermore, electricity consumption is found to Granger cause $CO_2$ emissions in India, while there is no Granger causality between electricity consumption and $CO_2$ emissions in Brazil, Russia, China and South Africa. Therefore, the differing results for the BRICS countries imply that policies cannot be uniformly implemented as they will have different effects in each of the BRICS countries under study.



## 1. Introduction

With increasing levels of industrialisation, a rapidly climbing global population, changes in lifestyle and rising levels of electricity consumption, the threat of global warming has grown over the last few decades. With the increased concern over the ability of energy supply to keep up with demand, combined with worries over global warming, the study of the relationship between electricity consumption, economic growth and greenhouse gas (GHG) emissions has gained increasing amounts of attention (Ang, 2007; Soytas et al. 2007; Apergis et al. 2010, Lean and Smyth 2010; Menyah and Wolde-Rufael 2010, Pao and Tsai 2010; Al-mulali, 2011; Li et al. 2011, Pao et al. 2011; Pao and Tsai 2011; Akpan and Akpan 2012; El Hedi Arouri et al. 2012; Farhani and Ben Rejeb 2012; Ozturk and Uddin 2012; Chang and Wolde-Rufael, 2013).

During the Fifth BRICS (Brazil, Russia, India, China and South Africa) Summit, held in Durban in March 2013, the delegations from the BRICS countries acknowledged that "climate change is one of the greatest challenges and threats towards achieving sustainable development" (Fifth BRICS Summit, 2013). Accordingly, the delegates from the BRICS countries have signed a "multilateral agreement on climate co-operation and the green economy", which will ensure the exchange of technical and financial support to combat the negative impact of climate change

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on developing countries (South African Government News Agency, 2013). Due to recent economic growth and the fact that the BRICS countries still use large quantities of fossil fuels for electricity generation, emissions are expected to increase contributing further to global warming.

The direction of causality between economic growth, electricity consumption and $CO_2$ emissions is important for the implementation of related policies. If, for example, electricity consumption causes economic growth, the country would have to implement expansive energy policies. If electricity also causes $CO_2$ emissions, then the country would rather have to invest in increasing electricity efficiency in order to decrease emissions without negatively impacting economic growth. If, on the other hand, economic growth causes electricity consumption, then conservative energy policies can be implemented without any adverse effect on economic growth. If there is no causality between these variables, then the country will have to implement separate policies to affect the levels of the individual variables as a change in the levels of one of the variables will have no impact on the other variable. Finally, if there is bidirectional causality between any of these variables, then they are mutually affected and policies need to take into consideration that any change in one will impact the other.

This paper re-investigates the relationship between electricity consumption, economic growth, and $CO_2$ emissions in the BRICS countries over the period of 1990–2010 by focusing on country-specific analysis. In detecting causal linkages the panel causality approach is applied. This approach is able to examine cross-state interrelations and country-specific heterogeneity, for example differences in energy resource endowments, energy policies, population size etc. The inclusion of $CO_2$ emissions as a third variable will help to prevent possible omitted variable bias that may occur in the bivariate case. It also makes sense to include this variable as all of the BRICS countries have an abundance of energy resources, mainly fossil fuels, which when used for electricity generation result in $CO_2$ emissions. In addition as mentioned earlier the BRICS countries have mutual agreements with regards to combating climate change and mitigate the effects of GHG emissions. Since the recent inclusion of South Africa into BRICS no study, to our knowledge, has been done using electricity consumption, economic growth and $CO_2$ emissions.

The plan of this paper is organised as follows. Section 2 follows as a literature review relating to energy consumption, economic growth and pollutant emissions. Section 3 presents the data used in this study and Section 4 briefly describes the bootstrap panel Granger causality test proposed by Kónya (2006). Section 5 presents the empirical results. Finally, Section 6 provides a discussion of the results of this paper's empirical findings and concludes the paper.

## 2. Literature review

The literature has shown extensive interest in the relationship between electricity, $CO_2$ and economic growth. The literature can be divided into three strands of study: first, the relationship between energy consumption and economic growth; second, the study of the economic growth-pollutant emissions nexus; and finally, the marriage of the first two strands into the study of the causal relationship between economic growth, pollutant emissions and economic growth.

The pioneering work with regards to the possible causal link between energy consumption and economic growth was introduced by Kraft and Kraft (1978). This paper studied the causal relationship between energy and Gross National Product (GNP) in the United States during the period 1947–1974. The main finding of the paper was that of unidirectional causality running from GNP to energy, without feedback. The conclusion reached was that government could pursue energy conservation policies without there being any negative effects on economic growth. Since then there has been an extensive amount of literature based on the causality between energy/electricity consumption and economic growth.

The direction of causality is important as the energy policy implications are vastly different for each possible direction. The presence of bidirectional causality between energy consumption and economic growth, also called the feedback hypothesis, implies that energy consumption and economic growth are jointly affected by shocks and any conservative energy policies may have an adverse effect on economic growth (Paul and Battacharya, 2004; Apergis and Payne, 2009b; Narayan and Smyth, 2009; Odhiambo, 2009; Bildirici, 2012; Shahbaz et al., 2012). Unidirectional causality from energy consumption to economic growth, also known as the growth hypothesis, implies that the country is energy dependent and thus energy consumption has both a direct and indirect effect on economic growth. The growth hypothesis implies that any conservative energy policies will have an adverse effect on economic growth (Cheng, 1997; Apergis and Payne, 2010; Adebola, 2011; Masuduzzaman, 2012). However, if the unidirectional causality runs from economic growth to energy consumption, otherwise known as the conservation hypothesis, the economy is less-energy dependent and conservation of energy policies can be implemented with little or no adverse effects on economic growth (Zhang and Cheng, 2009; Shaari et al., 2012). Finally, in the absence of causality between economic growth and energy consumption, the neutrality hypothesis, there is no long-run relationship between the two variables and any energy consumption policies, whether they be expansive or conservative, will have no effect on economic growth (Wolde-Rufael, 2006; Acaravci and Ozturk, 2010).

The second strand of studies focuses on the relationship between economic growth and environmental degradation, with focus on pollutant emissions. The environmental Kuznets curve (EKC) is derived from the work done by Kuznets and Simon (1955) who postulated the inverted-U shape relationship between income inequality and economic development. The basic idea behind the EKC is that as a country's economy starts the process of industrialisation, resource extraction increases as income increases, thus raising the levels of pollution. As income increases further, people start becoming aware of the environmental quality and are now willing and able to pay for the use of cleaner energy sources e.g. hydro, solar and nuclear power, thus pollutant emissions decline after a certain point. Therefore, an inverted-U shape is realised. The original work proposing the inverted-U shape of the EKC hypothesis was done by Grossman and Krueger (1991) and since then there has been a vast amount of research done on the validity of the EKC hypothesis. The policy implication for the EKC is that ensuring economic growth will in the long-run improve the environment. Thus according to Beckerman (1992) the best way to decrease the levels of environmental pressure is for the country to become wealthy. Richmond and Kaufman (2006), Galeotti et al. (2009), Fodha and Zaghdoud (2010) and Akpan and Chuku (2011) have all attempted to test the possible existence of the EKC. The results of these studies have been mixed, even among the literature supporting the existence of the EKC, there is no agreement on the level of income where environmental degradation starts decreasing. Extensive reviews of the literature on the existence and robustness of the EKC are done by Dinda (2004) and Stern (2004).

The last strand of literature has resulted from the marriage of the first two strands of literature resulting in studies on the economic growth-energy consumption-pollutant emissions nexus.