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# Carbon emissions, energy consumption and output: A threshold analysis on the causal dynamics in emerging African economies



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## HIGHLIGHTS

- The paper examines the causal dynamics among output, energy demand and carbon emissions in the presence of regime shifts.
- Regime shift have significant effects on the nexus among energy use, real GDP and CO<sub>2</sub> emissions.
- Results suggest that structural changes in selected countries have both economic and environmental effects.
- Integration of energy and environmental policies into development plans is desirable.

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## ABSTRACT

Following the recent global economic downturn, attention has gradually shifted towards emerging economies which have experienced robust growth amidst sluggish growth of the world economy. A significant number of these emerging economies are in Africa. Rising growth in these economies is associated with surging demand for energy to propel the engines of growth, with direct implications on emissions into the atmosphere. Further, these economies are constantly being shaped by series of structural reforms with direct and indirect effects on growth, demand for energy, etc. To this end, this paper examines the causal dynamics among energy use, real GDP and CO<sub>2</sub> emissions in the presence of regime shifts in six emerging African economies using the Gregory and Hansen (1996a). *J. Econ.* 70, 99–126 threshold cointegration and the Toda and Yamamoto (1995). *J. Econometrics.* 66, 225–250 Granger causality techniques. Results confirm the presence of regime shift effects in the long run inter-linkages among energy use, real GDP and CO<sub>2</sub> emissions in the countries considered, thus indicating that structural changes have both economic and environmental effects. Hence, integration of energy and environmental policies into development plans is imperative towards attaining sustainable growth and development.

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## 1. Introduction

The role of energy in the efficient functioning of an economy cannot be overemphasized. In this modern era, energy has become the bloodline of most economies as it drives every sector of the economy (Mensah, 2013). Production, distribution and consumption of goods and services thrive heavily on energy. Thus energy is regarded as a key driver of growth, industrialization, and urbanization (Esso, 2010). Nonetheless, energy is not entirely an exogenous phenomena in any economic system. Whereas it exerts significant influences on economic activities, it is equally influenced by these activities. In other words, there are feedback loops in the impacts and hence it is necessary not to consider only the

effects of energy on economic activities but also the reverse impacts as well.

One of the key inter-linkages between energy and economic system is the tri-variate relationship that exists between energy consumption, growth of output and carbon dioxide emissions. The inter-linkages among these three variables are often intricate, owing to the dynamics of the feedback effects that exist among them. In the literature for instance, four main hypotheses have been documented on the nexus between energy consumption and economic growth, namely: energy-led-growth, conservation (growth-led-energy consumption), feedback and neutrality hypothesis (Apergis and Payne, 2009; Esso, 2010). The energy-led-growth hypothesis posits a one-way causality running from energy consumption to growth with no feedback effects: implying that conservation policies are inimical to growth. However, conservation hypothesis asserts that energy savings does not necessarily imply stunting growth since the direction of causality runs

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from growth to energy consumption<sup>1</sup>. The feedback hypothesis rather regards energy and growth as complementary factors exerting significant influences on each other. However, the neutrality view does not accept any form of inter-linkages between energy demand and output growth but instead views them as two exogenous forces (Esso, 2010).

Also, issues of global warming with its attendant effects of climate change imply that it is not enough to concentrate on the bivariate relationship between energy consumption and growth, but also to look at their implications on the environment via their contributions to atmospheric emissions, especially carbon dioxide. This therefore creates a multidimensional relationship among the variables. Burning of fossil fuels to produce energy, on one hand, is highly associated with increasing emission levels. On the other hand, as hypothesized by the Environmental Kuznet Curve (EKC) literature, increasing economic activity has direct impacts on emissions (environmental degradation). Moreover, increased emission levels with its associated climate change have implications on energy consumption and economic activity. This therefore implies that any policy instrument designed for the management of any of these factors must be comprehensive to incorporate all the dynamics rather than treating them in isolation. This is important because, for instance, reducing energy consumption as a way of reducing emissions from fossil fuels may impose a negative externality on economic growth since energy is an integral input in the production and consumption process.

Due to differences among countries, in terms of the economic structure (industrial base), energy sources and environmental conditions, countries may resort to different policy instruments and options towards reducing emission levels to enhance environmental quality. Hence it is important that studies that seek to examine the causal links amongst these factors be disaggregated at the country levels rather than global or regional levels.

The quest for rapid economic growth in emerging economies especially in Africa has varied implications on energy consumption and consequently environmental quality. Does the pursuance of rapid growth and its accompanying energy demand imply a trade off in environmental quality and vice versa? These nagging questions make it more interesting to examine the causal dynamics among economic growth, energy use and carbon dioxide emissions, especially in the context of emerging economies. More importantly, the growth of these economies is largely the result of the myriad of structural reforms implemented over the years, and these reforms have key influences on the entire structure of the economies, in terms of economic activity, environmental policy, energy consumption, inter alia. In other words, the exposure of these economies to economic crises and their ensuing structural (adjustment) policies have the potential to affect the trend behavior (dynamics) of economic fundamentals (GDP), energy consumption and carbon dioxide emissions. Even though the literature is replete with studies on the dual relationship between energy and growth and the tri-variate relationship between energy, emissions and growth, only a handful of literature (Esso, 2010) have examined the influence of structural reforms (breaks) on these relationships, thus neglecting the potential impact of regime shifts on the relationships.

In this vein, this paper seeks to contribute to this fledgling strand of literature by offering empirical evidence on the influence of regime shifts on the relationship between energy consumption, economic growth and carbon emissions in selected emerging economies in Africa. Our study differs from the work of Esso (2010) in the

sense that whereas the latter examined the effects of structural breaks on the energy-growth nexus, this study extends the framework to include carbon emissions rather than just the direct relationship between energy and growth. We argue that the tri-variate nexus is more appropriate in capturing all the dynamics than the direct bivariate relationship. This approach may also reduce the potential problem of omitted variable bias in the bivariate case.

Thus in this paper, we investigate the impact of structural reforms (regime shifts) on the relationship among energy use, carbon emissions and economic growth in six (6) emerging African economies – Egypt, Ghana, South Africa, Senegal, Nigeria, and Kenya – using the Gregory and Hansen (1996a) threshold cointegration approach and the Toda and Yamamoto (1995) Granger causality test. Specifically, we examine the long run and causal relationships among carbon emissions, energy consumption and economic growth in the presence of regime shifts. This paper is of key relevance to policy design as it seeks to highlight the influence of structural changes in the economy on the interactions between economic systems and the environment.

The rest of the paper is structured as follows: Section 2 gives an overview of the major structural reforms in the six countries under study. Section 3 presents the literature review, while Sections 4 and 5 deal with the empirical strategy and discussion of results respectively. Section 6 concludes the study with some policy recommendations.

## 2. Overview of structural reforms in selected emerging African economies

The world economy in the 1980s was one of external shocks (due to oil price crash), high interest rates and general economic decline (African Development Bank (AfDB), 2000). As a result, many economies especially in Africa which were exposed to the shocks on the external sector were badly hit and this led to a wave of reforms to salvage the dwindling economies to avert imminent collapse. Even beyond this era, the wave of reforms continues on the continent especially in the emerging economies as part of efforts to restructure the economies to engender high growth and sustainable development. This section provides a brief overview of structural reforms in the selected emerging economies of Africa over the past four decades. Fig. 1 shows the trends in real GDP growth in the selected countries over the period 1971–2009.

### 2.1. Egypt

The Egyptian economy did not respond favorably to external shocks of the late 1970s and 1980s as the economy was chocked with massive fiscal and current account deficits, which culminated in unsustainable external debt (African Development Bank (AfDB), 2000). According to the African Development Bank (AfDB) “between 1980/81 and 1990/91, the country’s external debt increased from \$22.1 billion to \$31.1 billion. At the same time, budget deficit averaged 18% of GDP annually. The rate of inflation had risen to more than 20% and open unemployment had risen to about 10% by 1990. In response to this crisis, the Government of Egypt decided to act decisively. A standby agreement was concluded with the International Monetary Fund (IMF) in May 1991 and an Economic Reform and Structural Adjustment Program (ERSAP) with the World Bank for the period 1991/92 to 1992/93” (African Development Bank (AfDB), 2000, p. 4). The main objectives of the reform were: stabilization of the economy to create the necessary ambience for macroeconomic balance and reduce rising inflation; stimulate medium and long term growth; and a modification of social policies to minimize transitory effects of

<sup>1</sup> Thus the conservation hypothesis is in line with the argument that rising growth will exert a positive influence on energy demand, hence there is the need to conserve energy to meet future demands.

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