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Electricity crisis and the effect of CO2 emissions on infrastructure-growth nexus in Sub Saharan Africa

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ABSTRACT

Sub Saharan Africa (SSA) has the greatest proportion of its population without access to electricity, especially those in rural communities. Efficiency of the power sector is another obstacle, characterised by rise in the ratio of electricity transmission and distribution losses (RETDL) and high levels of electricity-related CO2 emissions. In view of these challenges, this study analyses the extent of electricity shortage, efficiency, key sources and opportunities for SSA in comparison with other regions. Two Stage Least Squares (2SLS) is used to examine the economic growth effects of electricity consumption (stock) and RETDL (quality), and how electricity-related CO2 emissions alter the growth contributions of both electricity consumption and RETDL. Our analysis indicate that SSA is mainly coal energy driven while the proportion of renewable energy is very low. Among the solid fuel sources, coal is the major cause of high levels of electricity-related CO2 emissions. The percentage of electricity from renewable sources (excluding hydro) is very low in SSA, second lowest from Middle East and North Africa (MENA). However, the region presents a great opportunity from its abundant renewable resources that can be exploited. Furthermore, electricity consumption has a positive impact on economic growth whereas the RETDL exerts a negative pressure on growth. Thus, deterioration in electricity quality reduces economic growth. High levels of electricity-related CO2 emissions lower the growth contributions of electricity consumption and exacerbate the negative growth impact of electricity quality. For the sake of sustainability and clean energy, SSA must invest substantially in renewable energy, which reduces its reliance on non-renewable energy in the long-term.

1. Introduction

Sub Saharan Africa (SSA) is a region of over 950 million people but also with the poorest access to electricity in the world [1]. The World Development Indicators reveal that carbon dioxide (CO2) emissions from electricity and heat production (CO2EM), and the ratio of electricity transmission and distribution losses (RETDL) have been rising in SSA over the past decades, implying deterioration in efficiency of the power sector. Poor electricity access remains the key obstacle to most businesses and economic growth in several SSA countries [2]. Potential threats from greenhouse gases are associated with substantial negative impact in SSA given persistent rise in CO2EM in the region [3]. CO2 emissions cause environmental problems and to mitigate their consequences, many nations have signed the Kyoto Protocol and pledged to lessen their emissions [4].

Recently, with increased focus on the Sustainable Development Goals (SDGs), studies on the impact of electricity consumption and CO2 emissions on economic growth remain vital to inspire energy policy and academic research. Interest in the potential nexus between electricity consumption, CO2 emissions and growth is traced back to the 1970s when scholars begun to notice the probable connection between these variables [5]. Several studies have empirically tested the environmental Kuznets curve (EKC) that hypothesises environmental quality and economic growth nexus. The EKC suggests that environmental degradation initially increases and then declines as growth per capita continues to rise. Since then, a number of studies have investigated the cointegration between electricity, CO2 emissions and growth [for example, 3,6,7], and/or the direction of causality between these variables [for example, 4,8,9].

Despite considerable amount of extant studies, firstly, accounting for electricity quality is still lacking and remains a serious gap in the empirical literature. Secondly, measuring both the nature and size of the influence of electricity-related CO2 emissions on the growth contributions of electricity stock (quantity) and quality is another angle that has not been properly interrogated in the literature. Given these gaps, this paper investigates the economic growth effects of both electricity stock and quality. While most existing research is on the direct impact of CO2 emissions on economic growth, to the best of our

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knowledge, investigation of the nature and size of CO2EM's influence on the growth contributions of both electricity stock and quality has not been done. Electricity consumption per capita is used as a proxy for the stock variable while the RETDL is the quality variable. Addressing these major concerns in our view will help illuminate trajectories of energy policy in SSA, especially in the light of the serious shortage of electricity and high levels of CO2 emissions from electricity and heat production.

The rest of the study is organised as follows: Section two gives a brief literature survey. Section three provides an overview of the electricity shortage and efficiency in SSA. Section four presents our approach for the influence of electricity-related CO2 emissions on the growth contributions of electricity stock and quality. Section five discusses the key findings of the study. Finally, the conclusions and policy implications are provided in section six.

2. Brief review of literature

It is imperative to highlight briefly the Environmental Kuznets Curve (EKC) hypothesis that involves the connection between economic growth and environmental quality. This research cannot go into detail since the validation of the EKC is not relevant here. The concept of the EKC emerged from the work of Grossman and Krueger [10] on the environmental impacts of a North American Free Trade Agreement (NAFTA). The EKC was named after Kuznets [11] who postulated an inverted U-shaped relationship between income inequality and economic development [see also 12].

The EKC hypothesises the relationship between growth in per capita income and environmental degradation which is believed to be inverted U-shaped. The notion behind this theory is that in the early stages of development when primary production is the key, there is plenty of natural resources and partial generation of waste due to less economic activity [13]. As economic development progresses, with industrialisation taking place, there is significant depletion of resources and accumulation of wastes. A positive link between growth per capita and environmental degradation occurs in this phase. However, based on this theory, further economic development is expected to overcome environmental degradation that took place in the initial stages of economic growth and hence producing an inverted U-shaped relationship between growth per capita and environmental degradation. In other words, at higher levels of economic development associated with enforcement of environmental regulations, environmental awareness, higher environmental expenditures and improved technology, environmental degradation declines [see 14]. The implication of the EKC hypothesis is that economic development is not a threat to global sustainability [15]. In other words, if this inverted U-shaped curve holds, instead of being an environmental risk (as claimed by environmentalists), economic development would be the means to ultimate environmental improvement [16].

Since the inception of the EKC concept, quite a number of empirical studies have investigated the validity of this curve. While others [for instance, 3,17,18–21] found the validity of this hypothesis, some [for instance, 15,22–25] did not find evidence for the inverted U-shaped relationship between pollutants and income.

Electricity and heat production being among the key sources of CO2 emissions, a body of empirical studies investigated the relationships between electricity, CO2 emissions and growth. Among the recent literature, using the autoregressive distributed lag model and vector error correction model, Ahmad et al. [7] revealed the existence of a long-run cointegrating relationship between energy consumption, CO2 emissions and economic growth, and the validation of the Kuznets curve. Moreover, they found feedback effects between CO2 emissions and growth, and positive nexus between energy and CO2 emissions. Salahuddin et al. [9] examined the link between CO2 emissions, electricity consumption, economic growth and financial development in the Gulf Cooperation Council (GCC). Their results suggested that economic growth and electricity consumption are positively related with CO2 emissions while financial development negatively impact CO2 emissions. These authors also found evidence for causality from electricity to CO2 emissions, and a two-way causality link between growth and CO2 emissions.

In Saudi Arabia, Mezghani and Haddad [5] found that huge volatility of electricity consumption tend to have negative impacts on oil GDP and CO2 emissions while it positively impact the non-oil GDP. Additionally, low and high volatility of oil GDP were found to have positive effects on CO2 emissions and electricity consumption. More so, the results of Apergis and Payne [26] suggested a positive relationship between energy consumption and CO2 emissions, with output showing the EKC hypothesis in the long-run. This includes a one way causality relationship from electricity consumption to real output. Kim and Baek [27] demonstrated that a rise in energy consumption can damage environment in the long-run. Analysing the Turkish power sector, Atilgan and Azapagic's [28] findings indicated that fossil fuels are accountable for roughly 88–99.9% of environmental effect related to electricity generation. From economic assessment, their results suggested capital costs of US$69.3billion for 49524 MW of installed capacity in 2010, by which hydro, coal and gas contributed 43%, 31% and 22%, respectively.

Cowan et al. [8] investigated the connection between CO2 emissions, electricity consumption and growth in BRICS economies. In terms of electricity-growth relationship, they found evidence for the conservation hypothesis in South Africa, feedback hypothesis in Russia and neutral hypothesis in India, China and Brazil. For the CO2 emissions-GDP connection, mixed outcomes were shown, that is, GDP to CO2 emissions (South Africa), CO2 emissions to GDP (Brazil), feedback hypothesis (Russia) and no Granger causality (China and India). In the African context, Bouznit and Pablo-Romero [20] confirmed the validity of the EKC in Algeria, however, with a turning point attained for a very high growth per capita so that growth continues to increase emissions. Furthermore, there was evidence of increased electricity consumption raising CO2 emissions. The inverted U-shaped hypothesis was also documented in Kais and Sami's [29] work. In a number of SSA countries, Esso and Keho [4] found power consumption and growth to be associated with rise in pollution in the long-run.

Based on 30 Chinese provinces, an analysis by Ding and Li [30] suggested that economic development factors are the greatest drivers for regional emissions compared to structural change factors, energy intensity and social transition. Moreover, urbanisation was found to contribute to emissions via changes in energy use characteristics of business sectors, transportation and urban households, among other factors. Rue du Can et al. [31] indicated that when allocating CO2 emissions based on end-user sectors, the share of building sector rises the most from 9% (direct emissions alone) to 31% (including indirect emissions), showing the great share of electricity and heat utilised by this sector.

Finding suitable strategies to reduce CO2 emissions is another key issue. Li et al. [32] found carbon pricing to be an effective measure to lowering CO2 emissions in China, in which the reduction ranges from 6.8% to 11.2% in the short-run. They also mentioned that in the long and mid-term, the effective policy is to target carbon revenue with competitive price of electricity. Wu et al. [33] demonstrated that amending the structure of energy to utilize renewable energy and recycling solid waste can substantially lower CO2 emissions.

3. Overview of electricity shortage and efficiency

3.1. Electricity shortage

Among the infrastructure problems, the shortage of electricity is a major hindrance to businesses and household welfare in SSA. Irrespective of a considerable rise in the population with access to electricity in SSA, approximately 530 million persons remain without electricity in 2014, very far from the desirable progress [34]. Given the