



Causal independence between energy consumption and economic growth in Liberia: Evidence from a non-parametric bootstrapped causality test

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H I G H L I G H T S

- ▶ Causality between energy consumption and economic growth in Liberia investigated.
- ▶ There is bidirectional causality between energy consumption and economic growth.
- ▶ Energy expansion policies are necessary to cope with demand from economic growth.
- ▶ Asymptotic Granger causality test suffers size distortion problem for Liberian data.
- ▶ The bootstrap methodology employed in our study is more appropriate.

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This contribution investigates causal interdependence between energy consumption and economic growth in Liberia and proposes application of a bootstrap methodology. To better reflect causality, employment is incorporated as additional variable. The study demonstrates evidence of distinct bidirectional Granger causality between energy consumption and economic growth. Additionally, the results show that employment in Liberia Granger causes economic growth and apply irrespective of the short-run or long-run. Evidence from a Monte Carlo experiment reveals that the asymptotic Granger causality test suffers size distortion problem for Liberian data, suggesting that the bootstrap technique employed in this study is more appropriate. Given the empirical results, implications are that energy expansion policies like energy subsidy or low energy tariff for instance, would be necessary to cope with demand exerted as a result of economic growth in Liberia. Furthermore, Liberia might have the performance of its employment generation on the economy partly determined by adequate energy. Therefore, it seems fully justified that a quick shift towards energy production based on clean energy sources may significantly slow down economic growth in Liberia. Hence, the government's target to implement a long-term strategy to make Liberia a carbon neutral country, and eventually less carbon dependent by 2050 is understandable.

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1. Introduction

Since the 1970s oil price shocks and the seminal work of Kraft and Kraft's (1978), a number of studies have attempted to examine the causal relationship between energy consumption and economic growth in both developed and developing countries. This interest has not only been fueled by the increasing economic activities across countries which have triggered a growing demand for energy across the world, but also the notion

that energy prices directly affect spending decisions of households, firms, and the overall performance of the economy. In fact, research examining the causal relationship between energy consumption and economic growth should be of interest to both economists and policy makers due to the significant implications for governmental energy policy (for example see Narayan and Smyth, 2005). However, the question one may ask is which variable causes the other? Does the use of energy lead to economic growth or does economic growth lead to energy consumption? The literature regarding the causal relationship between energy consumption and economic growth includes studies for OPEC countries, G7 countries, Asian countries, African countries, etc. In his study "A literature survey on energy-growth nexus", Ozturk (2010) noted that the literature produced

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conflicting results and there is no consensus, neither on the existence nor on the direction of causality between energy consumption (electricity consumption) and economic growth. In fact, there are currently four views. The first view preaches a unidirectional causality running from economic growth to energy usage and that as the economy grows the demand for energy from different sections of the economy increases. This means that the economy is non dependent on energy and that a continuous increase in GDP may imply a permanent increase in energy consumption. The second view, however, argues a unidirectional causality running from energy usage to GDP growth which means that it is the consumption of energy that causes economic growth. Better still, the third argument emphasize a bi-directional causality relationship between energy usage and economic growth. This means that both energy consumption and economic growth cause each other. Contrary to these three views which support some form of causal relationship between energy consumption and economic growth, the fourth and less probable view contends that there is no interdependence between energy consumption and economic growth. In other words, both energy consumption and economic growth are neutral with respect to each other.

Like developed and other developing countries, Africa is no exception to the above debate. In fact, recent empirical studies on the relationship between energy consumption and economic growth in African countries failed to reach a consensus as to the direction of causation. What is even more shocking is that, up to now and to the best of our knowledge there is no extensive study about links between growth and energy consumption for the oldest independent African country currently in transition – Liberia. Recognition of energy usage – economic growth links is very important for countries in transition like Liberia, which experienced recent years of civil war and a slow-down in economic growth. It therefore seems fully justified to examine in particular whether the economic growth in Liberia depends on the level of energy consumption. Answering this question is crucial not only for the Liberian energy policy but also for the energy policies of other African countries in the context of Africa's goal of a substantial reduction of greenhouse gas emissions.

In the literature, the most popular approaches for establishing causal interdependence between variables have been the traditional parametric approaches (like the traditional Granger and the Toda and Yamamoto approaches) which are based on asymptotic theory. As a matter of fact, all studies on causal independence in the context of African countries have used the traditional parametric approach. While traditional approach to testing for Granger causality is appealing, since the test reduces to determining the significance of the coefficients of the terms in the regression that depend on past and current values of the dependent variable, it can be said however that the methods describe above have several drawbacks. First, parametric tests require modeling assumptions (such as linearity of the regression structure, etc.) and hence, the application of asymptotic theory may lead to spurious results if suitable modeling assumptions do not hold (see Hacker and Hatemi, 2003). Second, even if all modeling assumptions are generally fulfilled, it is now known that the distribution of the test statistic may still be significantly different from an asymptotic pattern when dealing with extremely small samples (see Gurgul and Lach, 2012), a situation which is typical of most countries including African countries. Third, parametric tests based on prediction errors will be sensitive only to causality in the mean, while higher order structure such as heteroskedasticity, will be ignored (see Diks and DeGoede, 2001; Diks and Panchenko, 2006). Hence, this suggests that in order to obtain more robust estimates of causality would require implementation of a more general testing method which is sensitive also to nonlinear causal relationships and overcomes the above difficulties.

In order to examine the Granger causality relationship between energy consumption and economic growth in Liberia, this paper employs an alternative testing method which departs from standard traditional approaches. Efron (1979) pioneer a bootstrap testing technique which is less sensitive to possible model misspecification such as neglected nonlinearity, time series properties and size distortion. These features make application of the non-parametric bootstrap technique particularly attractive for a country like Liberia not least because of the need to adopt a different testing technique (as suggested by Ozturk, 2010) but largely because of the relatively small sample size (only 29 observations in our case) as well as evidence of heteroskedacity in the data (as revealed by White's heteroskedacity test). Unlike parametric approaches, the method is used for estimating the distribution of a test statistic by resampling the data non-parametrically. Since the estimated distribution depends only on the available dataset, it may be reasonable to expect that the bootstrap approach does not require such strong assumptions as parametric methods. Even though this approach has been shown to reduce size distortions (as we also show in this paper) and is believed to provide more precise test inferences than the asymptotic method in many applications especially when the available sample size is small (Hacker and Hatemi, 2003, 2006; Mantalos, 2000; Horowitz, 1994; Mantalos and Sukur, 1998), our paper will be the first application of the bootstrap technique to any African country.

Summarizing the main results, we find evidence in favor of bidirectional Granger causality between energy consumption and economic growth in Liberia. In addition, the results show that employment in Liberia Granger causes economic growth. The results apply irrespective of whether the causality is estimated in the short-run or in the long-run formulation.

To explore the potential benefit of using a bootstrap method in estimating the causal links between energy consumption and economic growth in Liberia, we examine its test size and power properties¹ relative to the asymptotic method. To this end, we conduct a Monte Carlo experiment to investigate whether the asymptotic test has larger size distortion than the bootstrap test in this application. Results from the experiment show that the asymptotic test has larger size distortion than the bootstrap test thus implying that the asymptotic Granger causality test suffers size distortion problem for Liberian data. Hence, this suggests that the bootstrap methodology employed in this study is more appropriate.

The rest of this paper is organized as follows: Section 2 presents an overview of the energy sector in Liberia. A review of the literature on energy consumption and economic growth in African countries is given in Section 3. Section 4 describes the traditional parametric and bootstrap Granger causality approaches. Section 5 provides a summary statistics of the data and the empirical results. Section 6 concludes the paper providing some policy implications.

2. An overview of the energy sector in Liberia

The energy sector is a driving force for nearly all socio-economic activities of Liberia as it propels industrial and commercial activities and enhances the delivery of basic social services. Modern energy services based on electricity and

¹ For more details surrounding this kind of test, interested readers are referred Horowitz (1995), Dolado and Lütkepohl (1996), Davidson and MacKinnon (1999), Mantalos (2000), Diks, and DeGoede (2001), Hacker and Hatemi, 2006, Lach (2010), etc. It should be mentioned that for the sake of conserving space, we only present Monte Carlo results for the primary energy consumption analysis. Results for total electricity consumption are available upon request from the authors.

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