# Renewable Energy, Financial Development and Real Per Capita GDP Growth in African Countries[1]

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**Research Article**

**Keywords:** renewable energy, financial development, real per capita growth, Pooled Mean Group, Augmented Mean Group, Dynamic OLS

**Posted Date:** March 14th, 2022

**DOI:** https://doi.org/10.21203/rs.3.rs-1343220/v1

# Abstract

This study examines the interrelation among renewable energy production, financial development and economic growth in 32 selected African countries for the period of 1996 to 2018. These countries are categorized on the basis of oil rich and non-oil rich as well as income levels. The study employs Pooled Mean Group, Augmented Mean Group and Dynamic OLS and key findings are established. The study reveals a positive and significant renewable energy-economic growth relationship in all the different groups. Financial development is found to improve economic performance in all categories except in non-oil rich African countries. This study thus recommends the restructuring of the energy pricing system, provision of long-term finance, adoption of risk mitigation instruments, improved institutional framework for private participation in renewable energy infrastructural development for growth sustainability in Africa.


# 1. Introduction

Access to sources of energy is an essential element for human welfare as well as economic development. One of the most pressing matters globally is making sure that everyone has sufficient energy. However, the rate at which energy is consumed has significant effect. Past and present energy systems are mostly characterised by fossil fuels including coal, oil and gas which are responsible for carbon-dioxide ($CO_2$) emission and emission of other greenhouse gases (Ritchie & Roser, 2015). In as much as there has been increased awareness over the years on the importance of renewable energy due to climate change, Africa accounts for a growing share in carbon emissions. This share increased from 3.3% of global energy-related $CO_2$ emissions in 2010 to 3.7% in 2018 with North Africa accounting for the largest share (International Energy Agency, 2019). Consequently, there is still much work to be done in terms of efficient energy use and accomplishing the Sustainable Development Goal of access to affordable, reliable and sustainable modern energy for all in 2030.

Different targets have been set to enhance energy efficiency and use of renewables as a result of growing awareness of the need for clean and sustainable energy for economic operations. These objectives are part of the United Nations' seventh Sustainable Development Goal, which aim to guarantee that everyone has access to cheap and clean energy. A significant goal in terms of energy efficiency is to double the worldwide rate of increase in energy efficiency from 1990 to 2010, which was 1.3 percent, by 2030 (IEA, 2019). In addition, this goal aspires to achieve a significant proportion of renewable energy in the global energy mix. However, in Africa there is still limited access to sources of electricity despite its vast potential. In 2018, electricity was unavailable to half of Africa's population (600 million people), and power outages were common in 80 percent of Sub-Saharan African countries, leading to economic losses (Eregha et al. 2021; Konyeaso, 2021). Thus, there is need for more study and more research to be done on how to lay more emphasis on renewable energy and how it will affect real per capita growth conditioned on financial development.

One of the ways of promoting sustainable energy use is through the use of renewable energy. The energy potential is especially true in the oil and gas rich North African region. These nations are located in the global Sunbelt with about 59% of their surface area estimated to have high potential for solar resource use: an estimated 150 000-terawatt hours per year. This is very high compared to the primary energy demand of 4400-terawatt hours per year (Poudineh et al., 2016). In addition, the proportion of renewables in the heating and transportation sectors lags far behind its potential capacity.

Several oil rich nations in Africa face the problem of inadequate capital investment into harnessing renewable energy resources as most of these countries are either into low or middle-income countries (Konyeaso, 2021). Most of the financing for energy and electricity generation is sourced through public funds. According to the International Energy Agency (2019), less than 40% of Sub-Saharan African governments do not permit private sector participation in energy generation and less than 20% of Sub-Saharan African nations do not allow private sector involvement in electricity transmission and distribution. In fact, some oil-rich African countries with a per capita GDP of over $12000 have the lowest renewable investment which implies that the constraint might also be a systemic one rather than only a financial one (Poudineh et al., 2016). Renewables, apart from reducing the amount of carbon emission, can contribute to diversification of economies by establishing new industries and expansion of the local value chain. This will also result in more employment opportunities. Many African countries also face the problem of poor public administration and institutions which hinder efficient energy management.

This study therefore focuses, in greater detail, the impact of renewable energy and financial development on real growth in both oil-rich and non-oil rich African nations as well as grouping these African nations into different income levels to further unravel the dynamic linkages among renewable energy, financial development and real growth for policy direction. To the best of our knowledge, no study has been done on a comparative analysis of oil and non-oil rich nations based on renewable energy production, nor on an examination of this connection among African countries on different income levels. This is the crux of this present study.

## 2. Empirical Review

The empirical literature is replete with mixed and imprecise findings across regions employing different methodologies on the renewable energy, financial development and growth connection. For instance, the ARDL methodology was used by Wang et al. (2021) on the interrelation among renewable energy usage, financial development and economic performance at the national and regional levels in China from 1997 to 2017. Economic performance was found to intensify renewable energy use while financial development adversely affected energy use. Li and Leung (2021) in a recent paper examined the dynamic relationship among energy prices, economic growth and renewable energy use in seven European countries with a granger causality approach. The study showed no indication of granger causation between renewables usage and economic output. The effect of renewable energy use on sustainable and inclusive growth was also examined by Kouton (2020) using a panel of 44 African nations for a period of 1991 to 2015. The System GMM (SGMM) result confirmed renewable energy to spur economic progress.

Though, the study failed to account for income levels, resource abundance, financial development and the panel unit root characteristics as well as cross-sectional dependence test. Chen et al. (2020) investigated the link between renewable energy usage and economic performance for a sample of 103-country sample from 1995 to 2015. The GMM approach showed renewable energy use to spur economic growth. Le et al. (2020) analysed the connections between renewable, non-renewable energy usage, economic growth and emissions in a sample of 102 nations. The Generalised Least Square (GLS) result showed renewable and non-renewable energy substantial impact on economic performance. Rahman and Velayutham (2020) studied the connection among renewable and non-renewable energy utilization and economic performance for a group of five Asian nations from 1990 to 2014 using FMOLS and DOLS. The outcome showed renewables and non-renewables to boost economic performance. Azam et al. (2020) examined the interrelationship between renewable energy generation and economic performance for 25 developing nations using the PMG approach from 1990 to 2017. The study revealed that renewable energy to cause long-run economic performance. Charfeddine and Kahia (2019) employed vector autoregressive model to investigate the impact of renewables and financial development on carbon emissions and economic growth in Middle Eastern and North African countries. Renewable energy utilisation and financial advancement were found to have minimal impact on economic performance. Mahi et al. (2019) investigated the relationship among energy use, financial development, and economic growth in five Asian countries from 1980 to 2017. The usage of a structural break revealed that the break has no effect on the association amongst energy, finance, and growth. Bekun et al. (2019) analysed the long-run relationship between renewable energy use, non-renewable energy use, and economic growth in a study for selected 16 European countries. The causality analysis indicated a feedback effect among economic growth, the usage of renewable energy and non-renewable consumption. Mensah et al. (2019) focusing on 22 Africa countries, examined the link among economic growth, fossil fuel energy consumption, carbon dioxide emissions, and oil price using PMG method. The study showed a long-term and short-term cause-and-effect relationship among oil prices, economic growth, fossil fuel energy use, and carbon emissions across these countries. Similarly, Singh et al. (2019) applying a Fully Modified OLS approach, discovered renewable energy production to positively influence economic growth in both developed and developing countries. Soava et al. (2018) examined the study looked at the relationship between renewable energy consumption and economic growth in 28 European Union nations from 1995–2015.. The empirical findings revealed renewable energy usage to favourably impact economic growth. Burakov and Fredin (2017) investigated the link among renewable energy utilization, financial advancement and economic progress using granger causality. The findings showed no significant causation running from renewable energy usage to economic growth. Esso and Keho (2016) examined the dynamic linkages among energy usage, economic growth and carbon emissions in selected African countries from 1970 to 2010. The outcome of the causality tests showed these variables to granger cause each other. Al-mulali et al. (2014) analyzed renewable and non-renewable power usage effect on economic growth in Latin American nations from 1980 to 2010. Based on the DOLS results, the study found renewable energy to boost economic growth more than non-renewable energy. Apergis and Payne (2012) used a multivariate technique to investigate the link between renewable energy use and economic performance in 80 countries from 1980 to 2007. The findings showed renewable energy sources to boost economic growth. Menyah and Wolde-Rufael (2010) examined the causal link between carbon dioxide emissions, renewable and nuclear energy consumption, and real GDP in the United States for the 1960–2007 using the Granger causality test. The findings revealed no causation between renewable energy usage, carbon emissions and GDP.

# 3. Model And Data

For the impact of renewable energy production and financial development on economic growth, this study focuses on the empirical specification of Singh et al. (2019) and Azam et al. (2021) which sets real GDP (G) as a function of gross capital formation (KC), labour (L) and renewable energy (RE).

$G = Af(KC, L, RE)$ … (1)

Expressing the above model in per capita terms:

$g_t = Af(kc, re)$… (2)

Financial development, which could affect the efficiency of technology (A), is integrated into the equation. Trade openness, which could also influence technological effectiveness, is included in the model as a control variable. Institution captured by regulatory quality (RQ) and voice and accountability (VA), are also controlled in the model. Institution spurs productivity for growth.

Regulatory quality denotes the capacity of the government to enact suitable policies for the improvement of the private sector. Voice and accountability refers to the ability of a country’s citizens to express their views of governance in an efficient manner. Regulatory quality is used as a metric of institutional quality because efficient policy formulation promotes the development and of the private sector and encourages private sector investment. Moreover, voice and accountability is also adopted in this study as an institutional quality metric because it also incorporates military participation in democracy and politics which increases corruption and reduces confidence of investors and capital inflow (Nadeem et al., 2020).

Thus, the empirical model is:

$Logg_t = \alpha_0 + \alpha_1 Logkc_{it} + \alpha_2 Logre_{it} + \alpha_3 LogFD_{it} + \alpha_4 LogTO_{it} + \alpha_5 LogRQ_{it} + \alpha_6 LogVA_{it} + \mu_t$ … (3)

Where $i = 1, …, N$ denotes the county and $t = 1, …, T$ denotes time

Table 1
Data and Sources

| Variable | Description | Measurement | Data Sources |
|---|---|---|---|
| g | Gross domestic product (GDP) per capita | GDP per capita (constant 2010 US$) | World Development Indicators |
| kc | Capital formation per head | Gross fixed capital formation per head (constant 2010 US$) | United Nations statistics |
| re | Renewable energy production per capita | Renewable energy power generation per head (kwH) | International Energy Agency |
| FD | Financial development | Monetary sector credit to private sector (% of GDP) | World Development indicators |
| TO | Trade openness | Exports of goods and services + imports of goods and services as a % of GDP | World Development Indicators |
| RQ | Regulatory quality | Regulatory Quality: Percentile Rank | World Governance Indicators |
| VA | Voice and Accountability | Voice and accountability: Percentile Rank | World Governance Indicators |

The study extracted data for 32 selected African countries[2] for the period of 1996 to 2018. The countries are grouped into oil-rich and non-oil rich as well as upper middle income, lower middle income and low income countries based on UN classification to allow comparative analysis.  The study first tests for cross-sectional dependency (CD), performs both first generation and second generation panel unit root tests, then employs the Dynamic OLS, Pooled Mean Group, and the Augmented Mean Group estimators selected based on the cross-sectional dependence test result and Hausman Test.  The Kao (1999) and Pedroni (1999) cointegration tests as well as the Westerlund (2005) cointegration test in the presence of CD are used.

**Footnote:**

[2] Nigeria, Algeria, Angola, Egypt, Ghana, Sudan, Equatorial Guinea, Republic of Congo, Cameroon, Libya, Gabon, Zambia, Mozambique, Namibia, Togo, Mauritius, Kenya, Botswana, Tanzania, Senegal, Benin, Sierra Leone, Burkina Faso, Uganda, South Africa, Comoros, Ethiopia, Madagascar, Lesotho, Central African Republic and Burundi

# 4. Empirical Analysis

In appendix A2, correlation results for each classification are presented as the first step to avoid problem of multicollinearity and the results confirm the absence of multicollinearity issue. Thus, we proceed with the empirical analysis.

# 4.1 Cross-Sectional Dependence Test

The study adopts the Pesaran CD test and the results are presented in Table 2 for each category.

Table 2
Cross-Section Dependence Test

| Panel Data Set | P-value | Statistic |
|---|---|---|
| Oil producing African countries | 0.21 | 1.26 |
| Non-oil producing African countries | 0.588 | -0.542 |
| Upper middle income African countries | 0.666 | 0.432 |
| Lower middle income African countries | 0 | 28.624 |
| Low-income African countries | 0.399 | -0.844 |
| Source: Authors’estimation output | | |

For lower middle-income countries, the null hypothesis of no cross-sectional dependency is rejected thus; second-generation unit root tests are employed carried out. For non-oil-rich, oil-rich, upper middle-income and low-income countries’ categories, we fail to reject the null hypothesis of no cross-sectional dependency, therefore, first-generation unit root tests is adopted.

# 4.2 Panel Data Unit Root Test

This study adopts the first-generation unit root tests [Levin et al. (2003), Breitung (2000) Im et al. (2003), ADF-Fisher and PP-Fisher test] for the category without cross-sectional dependence and the second-generation unit root test [Pesaran (2007)] for those with cross-sectional dependence. Tables 3 and 4 present the panel unit tests.

From the test results, it can be observed that all variables in the oil-rich African countries are stationary after 1st difference while the non-oil rich African countries have a mix of variables.

Also, series in the upper middle income African countries are integrated of order one while variables in both lower middle income African countries and low-income African countries have a combination I(1) and I(0).

# 4.3 Panel Cointegration Test

The cointegration tests used are Pedroni and Kao tests and Westerlund test (see, Table 5). From the results, cointegration is established for each of the categories depending on the test applied thus implying long-run relationship among the series in all the categories.

## 4.4 Estimation Results

From the Hausman test results, it can be observed that Pooled Mean Group is the preferred estimation technique as both p-values exceed 0.05. Tables 6 and 7 present the PMG, MG and Dynamic OLS results depending on each category according pre-estimation diagnosis.

For the oil producing African countries, renewable energy per capita is found to spur real Capita thus emphasizing the importance of African countries to develop the vast renewable energy deposit. A 1% surge in per capita renewable energy production will cause per capita GDP in oil rich African countries to increase by 0.062%. Also, financial development is found to be a growth driver. In fact, a 1% rise in financial development will improve per capita GDP by 0.016%. Similarly, regulatory quality and voice and accountability as institution variables in the model are found to be critical drivers of economic performance. For upper middle income African countries similar results are established. A 1% upsurge in renewable energy power generation per head will increase per capita GDP by 0.037%.. Also, a 1% increase in financial development will improve per capita income by 0.105%. For low-income African countries, per capita renewable energy production and financial development are found to positively influence, real per capita GDP and similar results are established for regulatory quality and voice and accountability. For non-oil rich African countries, renewable energy production per head, capital formation and voice and accountability contribute positively to growth in the long run but financial development had negative impact both in the short run and the long run on per capita GDP. Similar results are established for lower-middle income countries. Bayraktutan et al. (2011); Azam et al. (2020) and Singh et al. (2019) found similar results with renewable energy spurring real growth. Charfeddine and Kahia (2019) found financial development to improve economic performance while Bist (2018) found contrary view which is consistent with our finding.

# 5. Conclusion

The impact of renewable energy production and financial development on real per capita growth is investigated for 32 selected African countries classified under oil-rich, non-oil rich and incomes. Depending on the pre-estimation diagnosis outcome for each category, the Dynamic OLS, Pooled Mean Group and the Augmented Mean Group estimators are deployed in the analysis and interesting results are established. The study reveals renewable energy production to spur real growth in all the different categories confirming the imperativeness of renewable energy. Also, financial development is found to improve economic performance in all different categories except for non-oil rich African countries where it is established to be a growth drag.

Thus, the study recommends the need to allow suitable energy pricing to attract private investment in renewable energy infrastructure in Africa. It is important to strike a balance between providing energy at an affordable rate and making sure the prices are not too low so that private investors will be encouraged. Effort should also be geared towards mitigating risks involved in renewable energy investment and develop the right institutional framework for private sector participation in renewable energy infrastructural development for growth sustainability in Africa.

# Declarations

### Ethics approval and consent to participate:

Not Applicable

### Consent for publication:

Not Applicable

### Availability of data and materials:

The data used in this study are available from the corresponding author on reasonable request


### Funding:

This research is fully funded by the University of Economics Ho Chi Minh City, Vietnam. The approved funding number is IBR_RF274


### Competing Interests:

The authors have no relevant financial or non-financial interests to disclose.

### Authors' Contributions:

All authors read and approved the final version. The first version was prepared by Konyeason Amarachi under the guidance of Perekunah Eregha as the conception was jointly conceived. Perekunah Eregha provided the literature and the estimation codes. Perekunah Eregha then reworked and improved the first version and it was proofread and significantly finalised by Xuan Vinh Vo. All authors read and approved the final manuscript.

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# Tables 3-7

Table 3-7 is available in the Supplemental Files section.

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