

The Role of Renewable Energy and Ecological Footprint on Economic Growth in Francophone African Countries in presence of Institutions

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The Role of Renewable Energy, Ecological Footprint and Institutions on Economic Growth in Francophone African Countries

Abstract

This paper analyses the role of renewable energy, ecological footprint, and institutions on economic growth (measured by GDP per capita) using the generalized method of moments (GMM) with data spanning from 2007 to 2015. The results pinpoint that renewable energy correlates with economic growth negatively, partly due to the high intake of wood biomass in these countries. This indicates that renewable energy consumption may lower the per capita income growth in these countries. While the ecological footprint is statistically significant, it relates to growth positively, signalling that economic growth emerges with environmental degradation. Among the institutional variables, voice and accountability, political stability, and the rule of law equally associate with economic growth positively. Meanwhile, the insignificant relationship between governance effectiveness, regulatory quality, control of corruption, and economic growth indicates the under-developed state of institutions in the Francophone African countries. Thus, strengthening the forms of institutions will promote growth in Francophone African countries. This study, therefore, corroborates the ongoing debate in the literature on the environment-growth nexus that economic growth not only emerges with environmental degradations but that it can be improved with the consumption of renewable energy and robust institutions. Consequently, it is recommended that policymakers develop policies that raise growth with a focus on improving the environment and institutions.

Keywords Renewable Energy, Ecological Footprint, Economic Growth, Institutions

JEL Classification E44, F36, G21, O15

1. INTRODUCTION

Economic growth refers to the sustained increase in the economic welfare of a nation together with changes in economic structures, be it public health, literacy, demography, and income (Neil & Paul, 2001). As economic transformations take place, so do the social, political, environmental, and cultural. In some situations, the government needs to raise growth in order to mitigate poverty. But for human being to exploit the natural resources to stimulate growth, a trade-off emerges between growth and environmental degradation (Galeotti, 2007). Consequently, the global economies face a dual challenge of raising growth and keeping environmental degradation under control (Chakravarty & Mandal, 2020). The environment-growth nexus (environmental Kuznets curve) was first introduced to examine the relationship between the per capita income and income inequality (Kuznets, 1955). This theory was later developed to study the long run association between economic growth and environmental quality (Grossman & Krueger, 1991). The theory postulates that in the early stage of economic development, per capita income increases with environmental pollution. In a later stage, any increase in per capita income lead to a corresponding fall in pollution. The reason being that, at the early stage of economic development, nations do not care for the quality of their environment. But when the economy develops, the demand for environmental quality turns to increase (Panayotou, 1994).

The trade-off between economic growth and environmental degradation requires that countries should focus on renewable energy (REN) to stimulate growth. This focus on REN is due to its less expensive nature and the fact that it emits fewer fossil fuels (Ocal & Aslan, 2013). By definition, renewable energy is viewed as the form of energy that is generated from eco-friendly sources with minimal pressure on the environment. It comprises of combustible renewables, waste (solid biomass, charcoal, renewable municipal waste, gas from biomass and liquid biomass), the hydro, solar, wind, and tide energy (Verbruggen et al., 2009). In terms of global potential, biomass, wind, and solar energy have a technical potential that may cover the current global electricity demand. At present, REN contributes close to 14% of global primary energy consumption. Its main contributions in Africa are traditional, mainly non-commercial biomass such as fuelwood, crop residues and dung (9.3%), hydropower (2.3%), and modern use of biomass (1.4%) (Junginger, 2005).

African countries are substantially blessed with REN sources such as hydropower, biomass, wind, and solar energy, most of which are under-exploited (Kouton, 2020b). Geothermal sources are common in East and South Africa; solar energy is available in North Africa and some parts of East and South Africa; wind resources are existing in Northern Africa. Despite these huge resource potentials, less than 7% of the African enormous hydro potential has been harnessed. Meanwhile, REN sources could contribute significantly to the development of the energy sector in Africa (Kouton, 2020b). It could provide an attractive environment with sound technological options in the electricity sector. It may equally offset a significant proportion of foreign exchange used for importing oil for electricity generation in most countries. In addition, REN technologies utilize locally available resources and may provide employment opportunities for the locals. However, the success of REN in most African countries has been restricted by a combination of factors that include poor infrastructure, high dependence on wood biomass, inadequate REN planning policies, and lack of coordination in linkage the REN program. Likewise, African countries are much more concerned about poverty alleviation and may not invest in renewable technologies that could decrease environmental degradation. Another serious point is that the utilization of

renewable energy is still in its early stage in Africa , and even those that existed are generally in the form of wood biomass ¹ (Maji & Sulaiman, 2019).

In addition to REN, ecological footprint (TEFP) could aid in mitigating the spread of pollution (Xue et al., 2021) in Africa. It captures other forms of environmental degradation and reflects the pressure of human activities on land (Danish et al., 2019). However, the concept of ecological footprint that has caught on in the West has not been the same in Africa, where sustainable development remains a challenge. Most foreign companies and private firms operating in Africa do not consider the sources of ecological pressure and often neglect the detrimental aspects of their standard practices. Although the ecological footprint in Africa is far less compared to the world average, it is currently increasing due to the high level of deforestation, rapid increase in population growth, and per-capita consumption (Abanda, 2012).

The fundamental reason for linking renewable energy, ecological footprint and economic growth is that renewable energy raises growth by improving environmental quality as it reduces the toxic greenhouse gas discharges (Zandi & Haseeb, 2019). In examining the relationship between REN, environmental quality, and economic growth, Brock & Taylor (2010) introduced the concept of green growth. This concept is used to measure the environment-growth nexus by employing pollution emissions and abatement as the main factors of production. The concept of green growth has risen as a modern tool to improve the previous growth models. It re-examines the numerous economic choices in meeting energy, agriculture, water needs, and resource requirements of economic growth in an environmentally friendly approach. In other words, the concept of green growth can give rise to two things: the reduction in poverty through economic growth and the tackling of resource scarcity through renewable energy and climate change via a sound institutional framework. Rothstein & Teorell (2008) argue that it is not just the lack of entrepreneurial skills or investment in physical and human capital that deters economic growth but the absence of institutional quality. Hodgson (1989) supports this view by linking economic growth to inherited institutions and social practice.

The British and French engaged considerably different administrative styles in managing their colonies. These different approaches left insightful and yet opposing legacies on the development trajectories in their former colonies (Meouloud et al., 2019). The French colonial system is associated with the direct rule, which focuses on solid centralization, with all colonial decision-making, including the legal system centralized in Paris (Meouloud et al., 2019). The benefit of this centralization system is the facilitation of cultural integration and the development of a stronger sense of national identity in all Francophone colonies (Akisik et al., 2020). On the negative side, the centralization strategy lessened the development of independent institutions in Francophone countries. On the other hand, The British colonial system was based on decentralization through indirect rule. This strategy, which employed indigenous African leadership including the kings, chiefs, and local institutions to, among other things, carry out British colonial policies, strengthen colonial government decrees, and maintain the legal system, led to the establishment of a sense of statehood rather than nationhood (Akisik et al., 2020). The British style focused on developing administrative capacity, fiscal and budgetary autonomy while, at the same time, discouraging the process of national integration and the emergence of national identities (Akisik et al., 2020).

¹ Biomass denotes the source of energy that is stored in plants absorpt from the sun during the process of photosynthesis (Sadi et al., 2016)

But today, many Francophone African countries are still using the CFA² franc as their local currency, with their foreign reserves guaranteed by France (Stasavage, 1997). This international financial scheme provides a mechanism in which France continues to shape the global business operations in these countries (Mudambi, 1998). The role of institutional quality on economic growth in 21³ Francophone African countries will be examined, but because of the problem of missing data the analysis is limited to 14 countries (Benin, Burkina Faso, Burundi, Cameroon, Comoros, Republic of Congo, Democratic Republic of Congo, Ivory Coast, Djibouti, Gabon, Guinea, Equatorial Guinea, Madagascar, Mali, Niger, Central African Republic, Rwanda, Senegal, Seychelles, Tchad and Togo). The focus on Francophone African countries is supported by the fact that these countries share the same monetary policy and are all colonized by France. Besides, their local currency is the CFA, and these countries have passed through comparable economic trajectories. In studying the nexus, it is essential to raise the following question: How do renewable energy and ecological footprint relate to economic growth? To what extent do the institutional characteristics of Francophone African countries relate to economic growth? This is among the exciting questions that this research aimed to address. As discussed in the literature section, the previous studies settled that institution relates to economic growth positively. (Daron Acemoglu, Simon Johnson, 2001), (Commander & Nikoloski, 2010), (Joao Tovar Jalles, 2011), (Siddiqui & Ahmed, 2013) and (Mbulawa, 2015).

This research aimed to cover two main gaps: the knowledge-based gap and the evidence-based gap. The knowledge-based gap arises because very few studies have jointly explored the relationship between REN, TEFP, institutions, and economic growth in Francophone African Countries (D. Anthony Miles, 2017). Even those that existed turn to focus on the bivariate model, such as energy-economic growth and environmental quality and foreign direct investment-growth and ecological quality (Magazzino, 2017), (Maji et al., 2019), (Ntanos et al., 2018), (Ali, 2018) and (Aali-Bujari et al., 2017). Secondly, the evidence-based gap occurs because the nexus between REN, TEFP and economic growth remained inconclusive (D. Anthony Miles, 2017). While past studies have shown that REN relates with economic growth positively (Aali-Bujari et al., 2017), (Ali, 2018), (Marinaş et al., 2018) and (Hundie, 2018), others have settled for a negative association between these constructs (Magazzino, 2017) and (Maji et al., 2019). Therefore, this study will add to the ongoing debate in literature by analysing the combined effect of REN, TEFP, and institutional quality on economic growth in 14 Francophone African countries. The rest of the paper is structured as follows: Section 2 covers the literature review, and section 3 presents the methodology. Section 4 sheds light on the analysis, while section 5 concludes with some policy recommendations.

2.1 Drivers of Economic Growth

This section provides review for the determinant of economic growth. It will aid researchers in finding whether REN, TEFP, and institutional quality are significant drivers of economic growth. The section first presents the relationship between REN and economic growth, followed by TEFP and economic growth and lastly institutional quality and economic growth.

² CFA stands for French Community in Africa

³ Data were missing in Seychelles, Senegal, Niger, Madagascar, Gabon, Djibouti and Comoros

2.1.1 Renewable Energy and Economic growth

Magazzino (2017) studies the nexus between REN and economic growth by employing the Italian time-series data from 1970–2007. The author finds that REN relates to economic growth negatively. Apart from testing the cointegration relationship, the author went further to test for the causal effects between the variables. He notes that a unidirectional causality runs from renewable energy consumption to economic growth. The author concludes that the negative outcome between the REN and economic growth is supported with the fact that the growth of Italy goes along with a reduction in the consumption of energy due to the shift toward less energy intensive service sectors. Maji et al. (2019) conduct similar study for a sample of 15 countries in West African countries using the dynamic panel data for the period 1995-2014. The authors note that REN relates to economic growth negatively. Meanwhile, they linked the negative association to the high consumption of wood biomass and the limited utilization of renewable sources of energy in this region. On a similarly note, Ocal & Aslan (2013) study the cointegration and causal relationship between REN and economic growth in Turkey with data that run from 1990 -2010. To test for cointegration, the authors employ the ARDL method and find that REN is negatively associated to economic growth and their Toda Yamamoto causality test reveal that a unidirectional causality runs from economic growth to REN. The authors state that REN might impact growth negatively due to its expensive nature in developing countries. These researchers settle that despite the negative relationship that is found between REN and economic growth, policy makers in Turkey should encourage the consumption of this type of energy since it emits less greenhouse gases. In the same research context, Ntanos et al. (2018) employ the descriptive statistic, cluster analysis and autoregressive distributed lag (ARDL) for a sample of 25 European countries. The authors find that a long-run relationship exists between the RE and economic growth. They also note that REN consumption was higher in countries with higher GDP, whereas countries with lower GDP turn to rely mostly on the consumption of non-REN. Based on this outcome, the researchers suggest that policies that favor the creation of a more friendly environment with large scale investment in REN should be encouraged in both high income and low income countries.

Marinaş et al. (2018) examine the relationship between REN and economic growth in 10 European countries with data that run from 1990-2014. Using panel analysis, the authors find that REN is independent to economic growth in Romania, and Bulgaria, meanwhile in Hungary, Lithuania and Slovenia, they are positively related to economic growth. The authors equally note that a unidirectional causality runs from economic growth to REN. They went further to suggest that more consumption of REN should be practiced since increase in the consumption of this energy source improves the forecast of economic growth, that in turn raise the quality of forecasting the REN consumption. Dees & Auktor (2018) employ similar method to find out whether renewable electricity have a negative impact on economic growth in Mena region, given the high investment in renewable energy. The authors find that renewable electricity and economic growth are positively related in most of the countries except Turkey. Thus, investing in renewable does not hinder growth in MENA countries but it rather reduces the domestic fossil fuel consumption and to meet-up with the increasing demand of energy in this region. In similar research context, Bhattacharya et al. (2016) examine the role of renewable energy on economic growth in 38 top REN consuming countries in panel framework, with data running from 1991-2012. To run the analysis, the authors first classified the selected countries into three groups. For the first group, the authors settle that renewable energy plays a positive role in stimulating growth in these group of countries. For the second growth, these researchers note that REN is negatively related to economic growth in four countries (India, USA, Ukrain

and Israel). According to these authors, the negatively association between these two constructs is due to the nature of the energy-mix and the current status of renewable energy in these countries. Based on this, these scholars suggest that the replacement of non-renewable with renewable energy may jeopardize economic growth and should thus follow a gradual process of deployment. For the third group, the authors find that no significant relationship exists between the renewable energy and economic growth. Kouton (2020) recently conduct a study to look at the role of renewable energy on economic growth in Ivory Coast using the techniques of autoregressive distributed lags (ARDL). The author equally note that the renewable energy is not significant to impact growth in this country. In this regard, he suggests that the reason of this insignificant relationship could be due to the non-effectiveness of renewable energy consumption in Ivory Coast.

In a similar research framework, Maji et al. (2019) investigate the role of renewable energy on economic growth in West Africa by employing panel data techniques. On the contrary, the authors observe that renewable energy influences economic growth negatively. The authors state that, the negative outcome is perhaps due to the nature of renewable energy used in this region, especially wood biomass with unclean and it highly polluting nature. Meanwhile, the utilization of clean energy sources like hydropower, solar and wind that are not harmful to human health and the environment are limited in West Africa. These researchers thus suggest that policy makers in West Africa should encourage the use of energy that is less harmful to human health and the environment. Apart from renewable energy, other study in literature focus on the role of energy consumption on economic growth. In this regard, Aali-Bujari et al. (2017) investigate the impact of energy consumption on economic growth from 1977-2014, using the panel data analysis. The authors note that energy consumption is positively related to economic growth in the long run. Similarly, Ali (2018) examines the variables that generate carbon emissions in France with focus on FDI, financial development, economic growth and energy consumption. The author demonstrates that energy consumption moves in a similar direction with carbon emissions.

2.1.2 Ecological Footprint and Economic growth

Wackernagel and Rees (1996) defined the ecological footprint (TEFP) as the total amount of productive land required to support the consumption of a given population in a sustainable way. Nowadays, Researchers, policymakers and scientist are increasingly using the ecological footprints (TEFP) to measure environmental quality (Hassan et al, 2019). This is because the TEFP encompasses other forms of environmental degradation apart from pollution emissions (Xue et al., 2021). In this regard, Aşici & Acar (2015) employ panel data analysis to examine the impact of the TEFP on per capita income in 116 countries. By using data that run from 2004-2008, the authors find that a positive relationship exists between economic growth and TEFP in the short run, but negatively in the long run. Chambers & Guo (2009) apply similar methods and find that TEFP relates positively to economic growth. Meanwhile, Charfeddine (2017) uses the Markov Switching Equilibrium Correction Model to examine the relationship between energy consumption, trade openness, economic growth, and TEFP in Qatar with data from 1970–2015. The author finds that the EKC with an inverted U-shape is not relevant to the TEFP. Meanwhile, Hassan et al. (2019) utilize the recent autoregressive distributive lag (ARDL) to study the effects of economic growth and natural resources on TEFP in Pakistan. On the contrary, the writers conclude that a negative association (inverted U-shape) exists amid economic growth and TEFP in the long term.

Apart from the TEFP, carbon dioxide emission is also used to measure environmental quality. In this regards, N. Agarwal (2012) analyses the relationship between economic growth, foreign direct investment (FDI),

financial development, and environmental quality (CO₂) in Malaysia from 1980-2008. Using the time-series data, the author finds that the EKC with an inverted U-shape is relevant in Malaysia. Employing a similar method, Phimphanthavong (2013) pinpoints that economic growth negatively relates to CO₂ emissions. Likewise, Bond et al. (2015) demonstrate that economic growth is detrimental to the environment, confirming the EKC's relevance in Australia. Meanwhile, Aboagye (2015) uses different statistical methods, particularly the panel data analysis with data from 1985-2010. The author equally confirms the EKC is presence for energy consumption but not for carbon dioxide emissions. Using similar variables for countries of the Congo Basin countries, Hilaire & Kaffo (2014) reveal that economic growth positively impacts CO₂ emissions. Meanwhile, Awad & Warsame (2017) survey the relationship between economic growth and CO₂ emissions for 54 nations in Africa with data ranging from 1990-2014. The authors employ the same method and find that economic growth emerges with CO₂ dioxide emissions in these countries. Moreover, Carillo & Maietta (2014) use similar variables and find that the EKC hypothesis is relevant in Italy. Meanwhile, Fakher & Abedi (2017) recently analyzed the role of economic growth, FDI on the environment's quality in developing countries with data that run from 1983-2013. The authors settle that economic growth positively relates to environmental quality, in the long run, thus supporting a U-shape relationship's relevance.

2.1.3 Institutions and Economic growth

Rothstein & Teorell (2008) argue that it is not only the lack of entrepreneurial skills or investment in physical and human capital that deters economic growth but the absence of institutional quality. Hodgson (1989) supports this view since several economic theorists and historians have linked economic development to inherited institutions and social practice. Meanwhile, Findlay (1990), as cited in (Yeager 2018), states that institutions in third world countries are characterized by a poor democracy, high-level dictatorship, lack of accountability, and corruption malpractices. Vedia-Jerez & Chasco (2016) perform panel data analysis on South American nations with data covering the period 1960-2008 in a two-equation framework. They note that physical capital, human capital, and sectorial exports are the key determinants of economic growth. Under the same research context, Fayissa & Nsiah (2013) employ panel data to investigate the impact of governance on the performance of countries in Sub Saharan Africa. The authors find that good governance accounts for the differences in African growth. These researchers further suggest that for African countries to realize rapid growth, quality governance is highly needed.

Siddiqui & Ahmed (2013) survey the influence of institutional variables on economic growth using 31 indicators in 84 countries for 5 years period. These authors used the methods of ordinary least square (OLS) and the generalized method of moments (GMM) and conclude that quality institutions have a positive impact on economic growth. In the same research field, Jalles (2011) employs the quality of governance in a panel of 72 developing countries from 1970-2005. The results demonstrate that countries with lower corruption turn to manage their debt efficiently, with a positive effect on growth. Meanwhile Acemoglu, Johnson & Robinson (2001) research the colonial origins of countries based on governance indicators to examine the relationship between the rule of law and economic growth. In their research, the authors used the mortality rate of colonizers' as a measurement of the rule of law. Besides, assuming that a better rule of law exists in countries where the colonizers have settled compared to those that they did not, the authors conclude that a better rule of law will lead to rapid economic growth. In the same scientific field, Mbulawa (2015) study the factors that determine economic growth in Southern Africa Development Community. The author finds that institutional quality generates a favorable environment for

enhancing economic growth. Likewise, Robinson, Acemoglu & Johnson (2004) also find similar result but add that, political institutions, cultural and geographical factors may also influence the economic performance of most countries. On the contrary, Commander & Nikoloski (2010) argue that institutions have a limited effect on economic growth.

2.1.4 Africa and the concept of Green Growth

In studying the relationship between environmental quality and economic growth, researchers mostly employ the Kuznets Curve theory. This theory was first used to examine the inverse association between economic growth and income inequality (Kuznets, 1955). It was later redeveloped to study the long-run nexus between economic growth and environmental quality (Grossman & Krueger, 1991). This theory postulates that the per capita income increases with the environmental pollution in the early stage of economic development. But in the process of development, any further increase in income is accompanied by a fall in environmental pollution. The reason being that, in the early stage of economic development, nations do not usually care for the quality of their environment, as more utilization of natural resources is essential in building up a nation. However, once a certain level of income is reached, countries try to care about the quality of their environment since certain environmental issues (pollutions and health problems) emerge with income.

Brock & Taylor (2010) were the first to introduce green growth, also known as the Green Solow growth model. This model modifies the Solow (1956) growth model with the introduction of the environmental quality indicators. In this model, the authors considered pollution emissions and abatement as factors of production. In terms of applicability, this model may be helpful for African countries in two ways: Firstly, African countries are increasingly becoming the sources of pollutants and global warming from the massive exploitation of natural resources. Even though the global emission of carbon dioxide in most African countries is low, their global emissions could be high if they still follow the conventional growth patterns (OECD Report, 2012). Secondly, African countries are confronted with extreme economic, financial, social, and environmental threats caused mainly by the poor utilization of energy, water uncertainty, climate change, and severe weather risks. Furthermore, African countries are quite sensitive to environmental hazards because these countries highly depend on exploiting their natural resources.

To tackle the problems mentioned above more sustainably, the concept of green growth has risen as a modern tool to improve the previous growth models (Brock & Taylor, 2010). This model re-examines the numerous economic choices in meeting energy, agriculture, water needs, and resource requirements of economic growth in an environmentally friendly approach. It provides a base for studying the interconnection between renewable energy, ecological footprint, and economic growth. According to the OECD Report (2012), applying the green growth model in Africa might be limited for several reasons. Firstly, African countries have just started to evaluate the opportunities, dangers, and undoubtedly meaning of a green economy pathway. Secondly, there is a significant concern on how green growth will help mitigate poverty in Africa since it requires more extra cost. Besides, there is fear that the technology used in most developing countries is not enough, and thus, African countries will not be able to compete with the advanced societies (OECD Report, 2012).

Nevertheless, in a situation where African countries manage their resources in a more efficient and sustainable approach, there will be a success in incorporating the green growth concept. As Zandi & Haseeb (2019) stated, by focusing on renewable energy and quality institutions, there is a high chance of generating sustainable

development and green growth in Africa. Because this study jointly examines the role of renewable energy, ecological footprint, and institution on economic growth, it slightly differs from the green growth model. The difference arises because we had introduced other institutional variables in the model to aid in developing sustainable and eco-friendly policies. Rothstein & Teorell (2008) argue that it is not just the lack of renewable technology and human capital that deters economic growth in Africa but the absence of institutional quality.

3. Methodology

This study employs the method of difference GMM to test the impact of renewable energy, ecological footprints on economic growth, with data running from 2007-2015 in Francophone African countries. It is hypothesized that economic growth is determined by renewable energy, ecological footprint, and institutional quality based on Brock & Taylor (2010). In other words, we hypothesized that renewable energy, ecological footprint and institutions relate to economic growth positively. The Generalized method of moments (GMM) is employed to survey the role of the above-mentioned variables on economic growth. This method is chosen based on its ability to tackle the heterogeneity problems of each country, the influence of unobservable characteristics, and the endogeneity problem among the variables (Ullah et al., 2018). Blundell & Bond (1998) and Arellano & Bond (1991) developed the generalized moments (GMM) to estimate dynamic panel data. This type of data is usually dynamic in the sense that it considered that the performance of a country will be influenced by its previous year value. Different sources of endogeneity, like, simultaneity, unobserved heterogeneity, and dynamic endogeneity, have prompted researchers to employ the GMM model in a dynamic framework, since it often generates consistent results (Ullah et al., 2018). The GMM methods employ the lags of the dependent variables as explanatory variables. The Lagged values of the dependent variables are therefore used as instruments to control for the endogenous relationship. These instruments are often called internal instruments (Ullah et al., 2018). The GMM method solves the endogeneity problems by internally transforming the data. Transformation is a statistical process by which the past value of a variable is subtracted from its present value until the number of observations is reduced (Roodman, 2009).

The analysis starts by looking at the correlation matrix, scattered plot and lastly the GMM models. Seven models will be estimated, using the GMM method as explained above. The first model is the baseline model and the remaining are obtained by interacting the baseline model with the institutional variables. However, this analysis is limited to 14 countries, because of the problem of missing data in all the 21 French colonies in Africa. The model is specified as:

$$GDPC_{it} = \alpha_1 GDPC_{it-1} + \alpha_2 REN_{it} + \alpha_3 TEF P_{it} + \alpha_4 X_{it} + \mu_i + \delta_i + \varepsilon_{it} \quad (1)$$

where $GDPC_{it}$ measures the GDP per capita; $GDPC_{it-1}$ is the lagged of GDP per capita, REN_{it} stands for renewable energy, and $TEFP_{it}$ represents the ecological footprint. Also, X_{it} is the vector of the control variables (institutions) and μ_i is the unobserved country-specific fixed effects. Likewise, δ_i stands for the time trend; $\alpha_1, \alpha_2, \alpha_3$ and α_4 are the estimated parameters and i is the number of cross-sections ($=1, \dots, N$). Lastly, t is the number of time series ($=1, \dots, T$) and ε , the error term.

Table 1 presents the variables and data sources. Here, economic growth (measured by GDP per capita) in constant 2010 is the dependent variable. In contrast, renewable energy, ecological footprint, and six institutional variables (control of corruption, governance effectiveness, regulatory quality, the rule of law, voice and accountability, and political stability) are the independent variables. The ecological footprint is used as proxy for

environmental quality. This variable is reliable in capturing the effect of environmental degradations on economic growth compared to carbon dioxide emissions (Xue et al., 2021), (Hassan et al., 2019), (Aşici & Acar, 2015) and (Chambers & Guo, 2009).

Table 1 Variables Description and Sources

Variables	Definition	Measurement	Sources
GDP per capita)	GDP per capita is gross domestic product divided by midyear population.	In constant 2010)	World Development Indicators (WDI)
Renewable Energy (REN)	Renewable energy consumption is the share of renewable energy in total final energy consumption.	In % of total final energy consumption	World Development Indicators (WDI)
Total Ecological Footprint (TEFP)	Ecological Footprint is a measure of how much people demand from biologically productive surfaces.	In global hectares.	Global Footprint Network (GFN)
Control of corruption (CC)	Reflects perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.	Estimated value (-2, 5) weak to (2, 5) strong	World Governance Indicators (WGI)
Government Effectiveness (GE)	Reflects perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures.	Estimated value (-2, 5) weak to (2, 5) strong	World Governance Indicators (WGI)
Regulatory Quality (RQ)	Reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development	Estimated value (-2, 5) weak to (2, 5) strong	World Governance Indicators (WGI)
Rules of Law (RL)	Reflects perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property right.	Estimated value (-2, 5) weak to (2, 5) strong	World Governance Indicators (WGI)
Voice and Accountability (VA)	Measures the extent in which a citizen participate in selecting their government, freedom of expression, freedom of association, and a free media.	Estimated value (-2, 5) weak to (2, 5) strong	World Governance Indicators (WGI)

Political Stability (PS)	Political Stability and Absence of Violence/Terrorism measures perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism.	Estimated value (-2, 5) weak to (2, 5) strong	World Governance Indicators (WGI)
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Source: Author's computations

4. Results and Discussion

Table 2 shows the correlation between REN, TEFP, institution and economic growth. It is noted that REN and TEFP relate to economic growth in opposite directions. Particularly, REN correlate negatively with economic growth while TEFP associates with it positively. Similarly, the indicators of institutions have a negative correlation with economic growth except for political stability and governance effectiveness.

Table 2 Correlation Matrix

	$GDPC_t$	REN_t	$TEFP_t$	VA_t	PS_t	GE_t	RQ_t	RL_t	CC_t
$GDPC_t$	1.000								
REN_t	-0.552	1.000							
$TEFP_t$	0.146	-0.380	1.000						
VA_t	-0.025	-0.590	0.333	1.000					
PS_t	0.285	-0.495	0.030	0.584	1.000				
GE_t	0.064	-0.208	-0.040	0.479	0.664	1.000			
RQ_t	-0.166	-0.205	0.054	0.601	0.649	0.860	1.000		
RL_t	-0.039	-0.275	-0.035	0.662	0.767	0.850	0.910	1.000	
CC_t	-0.139	-0.095	-0.157	0.367	0.571	0.861	0.860	0.849	1.000

Source: Author's computations

The positive association between the ecological footprints and economic growth, is reflected in the scatter plot of Figure 1, with a positive trend. Meanwhile, in Figure 2, we note that a negative correlation exists between renewable energy and economic growth. Albeit descriptive, the evidence mentioned above supports a positive linkage between ecological footprint and a country's GDP per capita. This implies that economic growth emerges with environmental degradation.

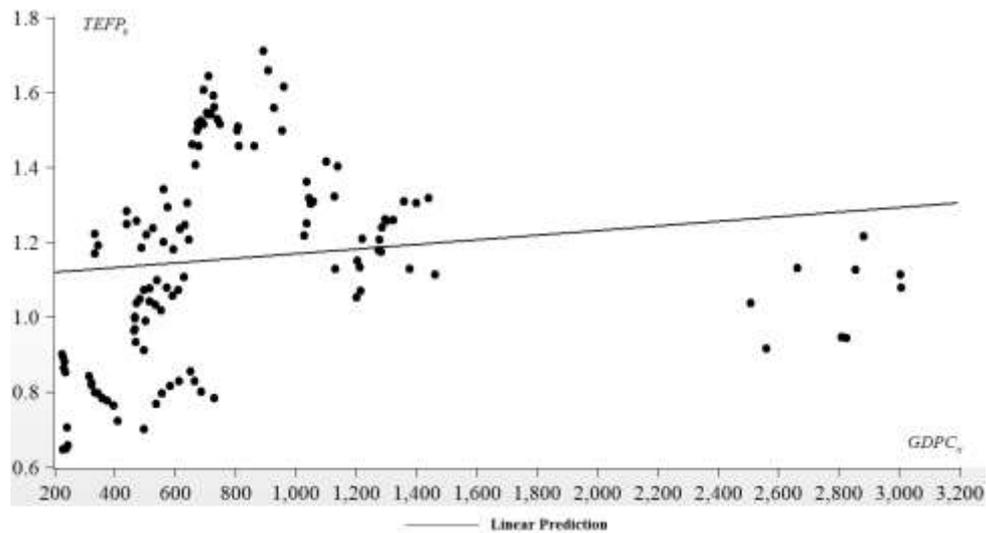


Fig. 1 Economic Growth and Ecological Footprint

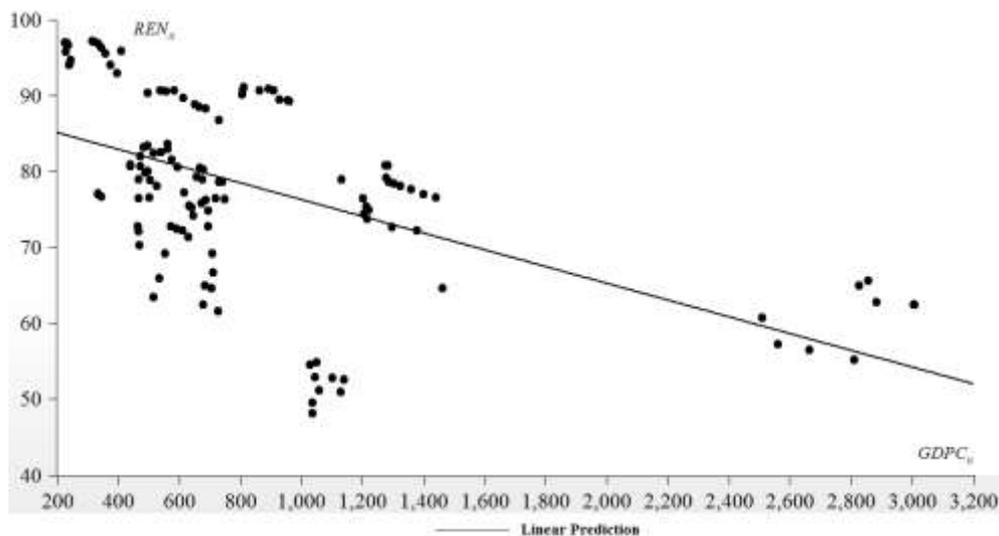


Fig. 2 Economic Growth and Renewable Energy

This study aimed to examine the role of REN, TEFP and institutions on economic growth (measured by per capita income) in 14 Francophone African countries using the generalized method of moments (GMM). The result of the dynamic model using the GMM is presented in Table 3. To identify the relevant determinants of economic growth, the baseline model is first estimated before interacting it with the institutional variables in chronological order. The baseline model is presented in column (1); meanwhile, column (2) to (7) are obtained by interacting it with the institutional variables. The result in column (1) to (7) pinpoints that all the lag values of per capita income are statistically significant. This indicates that the past income per capita level is a strong predictor of its current value. In other words, economic growth as measured by the per capita income tends to be somewhat path-dependent. This further pinpoints that a country's economic growth in the previous year tends to influence its growth level in the subsequent period.

Table 3 Difference GMM Estimates (Dependent Variable GDP per Capita (GDPC))

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GDP per Capita	0.962*** (0.06)	0.906*** (0.09)	0.943*** (0.07)	0.924** (0.09)	0.935** (0.07)	0.816*** (0.17)	0.946*** (0.06)
Renewable Energy	-6.229*** (2.22)	-5.726*** (1.77)	-6.325*** (1.95)	-5.593** (2.24)	-5.559** (2.29)	-5.399*** (1.52)	-6.251*** (2.34)
Total Ecological Footprint	241.2** (108.10)	219.9** (98.54)	251.0** (106.20)	225.8* (94.52)	247.6** (102.50)	231.8** (92.73)	237.1** (103.80)
Voice and Accountability		84.30** (36.19)					
Political Stability			22.20** (9.262)				
Governance Effectiveness				26.31 (42.20)			
Regulatory Quality					15.77 (34.42)		
Rule of Law						140.5** (65.43)	
Control of Corruption							40.63 (34.71)
Observation	98	98	98	98	98	98	98
Time Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Instrument	22	23	23	23	23	23	23
AR(1)	0.085 ^a	0.095 ^a	0.085 ^a	0.080 ^a	0.076 ^a	0.074 ^a	0.078 ^a
AR(2)	0.264 ^a	0.466 ^a	0.653 ^a	0.272 ^a	0.244 ^a	0.478 ^a	0.233 ^a
Hansen Test	0.891 ^a	0.883 ^a	0.985 ^a	0.976 ^a	0.880 ^a	0.950 ^a	0.894 ^a

Robust options used; standard errors in parentheses; *,**,*** represent significant at 1%, 5% and 10% respectively, while ^a stands for P-values. Estimations are done using *xtabond2* routine in Stata.

Source: Authors' computations.

The GMM result shows that renewable energy is negative and statistically significant in relating to economic growth. This shows that renewable energy tends to lower the level of per capita income growth in these countries. Meanwhile, the total ecological footprint was found to be positively related to economic growth in all the columns, indicating that economic growth turns to emerge with environmental degradations. Also, voice and accountability, political stability, and rule of law were equally statistically significant and positively related to economic growth; meanwhile, government effectiveness, regulatory quality, and control of corruption were found to be positive but not statistically significant. Given the choice of one lag, the AR(2) specification test results as disclose by the P-values, indicate that these model do not suffer from the second-order serial correlation problem, and the Hansen test results further reveal that the instruments used in this research are not over-identified. This thus pinpoints that a good statistical inference can be made from these results. Some interesting points can be deduced from these findings.

The negative association between renewable energy and economic growth implies that this variable turns to lower the level of per capita income in these countries. It was hypothesized that a positive association exists between renewable energy and economic growth but this finding is perhaps due to the high usage of wood biomass couple with the fact that the utilization of clean energy sources like solar, wind, and hydropower with fewer side effects on human health and the environment are scarce among the Francophone African countries. Moreover, the negative relationship might be as a result of the expensive nature in using the renewable sources of energy in these

countries. This finding is in line with those of Magazzino (2017) and Maji et al. (2019). As explained in the literature section, these findings support the relevance of growth hypothesis, where renewable energy relates to economic growth negatively. But it contradicts with the work of Aali-Bujari et al. (2017) and Ali (2018).

This result equally pinpoints that ecological footprint relates to economic growth positively, implying that economic growth raises environmental degradation in these countries. The findings that ecological footprint relates with economic growth negatively is supported by the works of Aşici & Acar (2015), Chambers & Guo (2009) and Fakher & Abedi (2017) but opposed those of Hassan et al. (2019) and Charfeddine (2017). For institutions, it is noted that voice and accountability, political stability and rule of law have a positive effect on economic growth. These findings are in line with Acemoglu & Johnson (2001), Siddiqui & Ahmed, (2013) and Mbulawa (2015). According to these results, strengthening the forms of institutions will promote economic growth within the Francophone African countries. Perhaps as Fayissa & Nsiah (2013) stated, good governance and income level accounts for the differences in economic growth among the African countries. In other words, without the establishment and maintenance of good institutions, achieving rapid growth and economic development will be limited in Africa. Meanwhile the insignificant relationship that we found between governance effectiveness, regulatory quality, control of corruption, and economic growth are likely indications of the under-developed state of institutions in the Francophone African countries. From these results, the strengthening of institutional forms and elimination of corruption, governance efficiencies, and providing good regulatory systems will promote economic growth in this region. Commander & Nikoloski (2010), also found similar results, where institution was insignificant in impacting growth.

5. Conclusion and policy implications

The objective of this study was to examine the role of renewable energy, ecological footprint, and institutional quality on economic growth in 14 Francophone African countries using the generalized method of moments (GMM). The result showed that renewable energy relates to economic growth negatively. This indicates that renewable energy tends to lower the level of per capita income growth in these countries. This outcome is perhaps due to the high usage of wood biomass and the limited consumption of renewable energy in these countries. For ecological footprint, we found that it correlates to economic growth positively, indicating that economic growth tends to emerge with environmental degradations.

Meanwhile, for institutional quality, we observed that voice and accountability, political stability, and the rule of law positively associate with economic growth; whereas, governance effectiveness, regulatory quality, and control of corruption were not statistically significant. These findings show that institutional quality has an essential role in enhancing or limiting the catch-up process (economic development). Thus, improving the corruption index, regulatory quality, accountability in public services, and political stability could boost this region's economic growth.

The main contribution of this study is that for the first time, an attempt has been made to examine the dynamic relationships between renewable energy, ecological footprint, institutional quality, and economic growth in 14 Francophone African countries using the generalized method of moment (GMM). This study's outcomes are useful to policymakers and Francophone African countries in developing policy that encourages environmentally friendly products with limited greenhouse gas emissions and to encourage the consumption of more renewable energy sources. In this regard, any reforms aimed to generate sustained growth in this region require that

policymakers improve institutional quality. Despite these contributions, this study has a few limitations. We encountered the problem of missing data in some Francophone African countries, the reason why the study is limited to 14 countries. Secondly, the estimation method (GMM) applied in this study is essential in solving the endogeneity problems, but it is limited in testing the causal effects between the variables. As a suggestion, future research could integrate more variables and states to measure the relationship between renewable energy, ecological footprint, and economic growth in this region. Likewise, future research should consider other methods that examine the causal effects between the variables.

Compliance with ethical standards

Conflict of interest No potential conflict of interest was reported by the author.

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