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Institutional quality and investment in renewable electricity in Sub-Saharan Africa

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Abstract

Even though investment in renewable electricity could potentially enhance access to electricity in Sub-Saharan Africa while contributing to the global fight against climate change, key drivers of renewable energy investment such as institutional quality have not been examined. This study investigates whether the quality of institutions matters in explaining investments in renewable electricity in Sub-Saharan Africa using panel data for the period 2000 to 2015 and the system generalized method of moment estimation technique. The results indicate that both economic and political institutional quality matter in renewable electricity investment in Sub-Saharan Africa. A unit increase in the quality of economic and political institutions leads to a 6% and 65% increase in installed capacity for renewable electricity respectively. Policy choices should focus on strengthening existing laws that will ensure improvement in property rights, financial freedom, fiscal freedom, civil liberties, political rights and labour legislation to induce investment in renewable electricity.

Keywords: *Renewable Electricity, Economic Institutional Quality, Political Institutional Quality and Installed Capacity*

1. Introduction

Electricity access and reliability remain one of the major challenges in sub-Saharan Africa (SSA). Electrification is low, that is 45% compared to the levels in other developing countries which hover around 94% (International Energy Agency (IEA), 2019). Even those connected to the grid are confronted with irregular and unreliable supplies. This has led to 595 million people not being connected to the grid due to the unavailability of electricity infrastructure with many of them being poor rural dwellers. Though electricity generation capacity for SSA (excluding South Africa) in 2040 is estimated to increase to 270 gigawatts (GW), it is considered inadequate to provide reliable and affordable electricity to meet increasing demand (IEA, 2019). The situation is even worst given the fact that over 90% of the world's population will be in developing countries by 2050 (World Bank, 2006). This suggests that increasing access to electricity is crucial.

In SSA, many industrial activities and electricity production rely heavily on the use of fossil fuels as they account for 80% of total energy sources for power supply compared to the average of 56% in developing countries (IEA, 2014). The over-dependence on fossil fuels results in environmental

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pollution that reverses the effort being made in climate change mitigation. Also, fluctuations in international oil prices pose a threat to energy security that SSA countries can barely manage based on the small country argument. Additionally, the current challenge posed by asset and resource stranding may affect SSA significantly if measures are not put in place to reduce the use of fossil fuels which is estimated to decline by 34% (Bos & Gupta, 2019).

Despite the problems associated with the use of fossil fuel and the huge potential that renewable energy hold in reducing energy poverty, ensuring electricity security, meeting international emission reduction agenda, as well as increasing electricity access to many poor households in the long–run, investment in renewable power generation in SSA has not received the needed attention. Renewable energy investment in Africa increased from US$10 billion in 2015 to about US$13 billion in 2020 and the total investment in 2020 is about 4% of the global investment in renewable electricity generation (International Renewable Energy Agency (IRENA), 2021).

With the current trend of investment in renewable electricity, significant efforts should be made by SSA to attract adequate investment in renewable electricity. Several factors determine investment in renewable energy including market structure, environmental policy, technological availability (Verdolini and Vona, 2015), Gros Domestic Product (GDP) per capita, electricity consumption, size of population (Popp et al., 2011) and institutional quality (Acemoglu et al., 2010). Even though institutional quality plays a significant role in renewable energy investment empirical studies have not paid much attention to it, especially within the context of SSA (Acemoglu et al., 2010). Most studies tend to focus on renewable energy consumption and production (Oluoch et al., 2021; Asongu and Odhiambo, 2021; Amoah et al., 2020; da Silver, 2018 and Baye et al., 2021), investors' behaviour and preferences for renewable energy (Stenzel and Frenzel, 2008). Marinescu and Fucec (2014) came close to the subject matter by establishing that the quality of economic institutions matters in the efficiency of renewable energy investment in five European countries.

A major setback of these studies is that they do not emphasize renewable electricity investment, place little emphasis on how the quality of economic and political institutions affect renewable electricity investment, place less focus on how long it takes for an investment to respond to changes in institutional quality (see Benassy-Quere et al., 2007; Ajide and Eregha, 2014; Nasir and Hassan, 2011 and Morrissey and Udomkedmongkol, 2012) and use estimation techniques that do not address endogeneity issues which is quite important in econometric estimations (Commander and Nikoloski, 2010; Meon and Sekkat, 2004).

The unavailability of studies on the role institutions play in renewable electricity investments has allowed many SSA countries to focus on factors such as market structures, GDP and energy consumption as the major justification for renewable energy investment to the detriment of equally important factors such as institutional quality relating to corruption, regulatory instruments that hinder the opportunities for businesses to retool and raise the responsiveness of investment to innovation shocks (Siba 2007; Englebert 2000).

This study aims at examining the effect of economic and political institutional quality on investment in renewable electricity in SSA. Analysis of this issue is imperative because renewable electricity technology requires large capital investment which is irreversible ((North and Weingast, 1989). Once undertaken its productive value in an alternative venture is lower than the investment cost. This makes governments behave opportunistically and not likely to credibly commit to agreements and policies relating to renewable energy development, especially in SA where institutional quality is weak. The results could therefore bring to the fore the economic and political institutional quality and renewable electricity dynamics and assist policymakers to strengthen existing policy and regulatory choices on renewable electricity investment and consequently improvement in access to electricity, the key focus of Sustainable Development Goals 7.

The remainder of this paper is organised as follows: the next section reviews the literature on institutional quality and investment to provide theoretical and empirical backing to the subject matter. This is followed by section 3 which discusses the methodology adopted for the study. Section 4 presents and discusses the results while the last section concludes and provides policy recommendations.

2. Literature review

The role of institutions as an issue of interest for both theoretical and empirical analysis dates back to the 1990s. The central question has been "what determines differences in the economic growth of countries over time? Issues relating to Africa's poor performance, East Asian financial crisis and the weak record of the former Soviet Union have been the reasons for increasing focus on the role of institutions in economic growth and performance (Aron, 2000). Theoretical studies emphasize that institutional quality impacts economic growth and development through channels such as investment and improvements in efficiency (Obinger, 2001; Henisz, 2000). This is reinforced by empirical studies that have investigated the potential of institutional quality to protect property rights (Acemoglu et al., 2001), ensure accessibility of savings for investment (Tchouassi, 2014) as well as rule of law (Acemoglu & Robinson, 2012).

Generally, investment is considered irreversible and could be affected when there are credibility issues, especially in situations where a government has incentives to alter regulations knowing that investors cannot simply pull out (Spiller, 1996; North & Weingast, 1989). Thus, good institutions induce investment as it provides security for contracts without unnecessarily ensuring a high cost of transactions. Also, institutional quality provides the opportunity for countries to assure property rights and to undertake coherent policies that can lead to increased income (North and Thomas, 1973; North, 1981). Although some studies on renewable energy have been carried out, there are scarce empirical studies that analyse institutional quality and renewable electricity investment. Studies tend to focus on institutional quality and Foreign Direct Investment (FDI) (Benassy-Quere et al., 2007; Daude and Stein, 2007; Ajide and Eregha, 2014; Nasir and Hassan, 2011; Morrissey & Udomkedmongkol, 2012; Hseieh & Klenow, 2007; Caetano and Caleiro, 2009; Bello and Subasat, 2011); income and renewable energy consumption (Apergis & Payne, 2010; Ohler & Fetters, 2014; Khobai 2018; Suberu et al., 2013; Rupf et al., 2016; da Silva et al., 2018) and renewable energy investment and consumption (Marinescu and Fucec, 2014; Amoah et al., 2020; Wu and Broadstock, 2015; Bhattacharya et al., 2017; Dasgupta et al., 2016, Ergun et al., 2019).

On institutional quality and foreign direct investment, Benassy-Quere et al., (2007) examined how institutions drive FDI for the period 1985-2000 using information from different databases and the two-stage least square (2SL) method. The authors established that institutions positively affect FDI with the key determinants being tax system, easiness to set up business, less red tape and transparency, among others. Similarly, Daude and Stein (2007) using bilateral FDI stock from countries in Organisation for Economic Co-operation and Development (OECD) and World Governance Indicators (WGI) developed by Kaufman et al., (1999) find that poor institutional quality such as excessive regulatory burden, deficient property rights assurance and less government commitment stifle FDI flows.

Using the fixed effect method and data from 12 Economic Community of West African States (ECOWAS) for the period 1995-2010, Ajide and Eregha (2014) investigate how economic freedom affects FDI inflows. They conclude that financial freedom positively and significantly affects FDI inflows. However, less business freedom and lack of enforcement of property rights reduce FDI inflows. They recommended improvement in business freedom and enforcement of copyright, patent and franchise rights.

Focusing on South Asian countries, Nasir and Hassan (2011) examine how economic freedom and exchange rate stability influence FDI using regression analysis and panel data for the period 1985-2008. Their findings suggest that economic freedom affects FDI inflows positively while trade openness and low corruption boost the trust of investors and consequently their business location. Using the same database of Economic Freedom Index (EFI) developed by the Heritage Foundation, Bengoa and Sanchez-Robles (2003) investigate the relationship between economic freedom and FDI for 18 Latin American countries using panel data from 1970 to1999. They find that economic freedom contributes positively to the inflows of FDI.

In a related study, Caetano and Caleiro (2009) analyse the impact of economic freedom on FDI inflows for Middle East and North African (MENA) and European Countries countries from 1992 to 2006 using FDI performance index by the United Nations Conference on Trade and Development and the EFI of Heritage Foundation. Based on fuzzy logic clustering method, they find that economic freedom and inward FDI are positively associated in the cluster of countries that present higher economic freedom. Using different measures of the EFI developed by the Frazer Institute, Bello and Subasat (2011), investigate the impact of economic freedom on FDI using Gravity Model over the period 1985 to 2005. They used both economic freedom variables developed by Fraser Institute and Heritage Foundation and employed the Generalised Least Square estimation technique. Their results support the early findings that economic freedom is an important determinant of FDI, however, their results cannot be generalised. They argue that countries with liberal trade regimes tend to attract more FDI. That is, FDI response positively and significantly to economic indicators such as government size and freedom to trade and negatively to regulatory quality.

With regards to income and renewable energy consumption, some studies have concentrated on how renewable energy consumption affects economic growth. For example, Khobai (2018) examines the relationship between electricity generated from renewable energy and economic growth in South Africa for the period 1997 to 2012. Using Johanson cointegration and Vector Error Correction Model (VECM) estimation techniques, they find a unidirectional association between electricity generated from renewable energy to economic growth. They recommended that the government should select appropriate policies relating to energy policies that enhance economic growth. Apergis and Payne (2010) investigated how renewable energy consumption relates to economic growth. They employed a panel cointegration and error correction model for 20 OECD countries from 1985 to 2005. Their findings suggest that the relationship between energy consumption and economic growth is bidirectional in the short and long run. In a related study, da Silva et al., (2018) examine the drivers of renewable energy growth in SSA from 1990 to 2014. They used a panel Autoregression Distribution Lag (ARDL) model and concluded that population growth impedes renewable energy development. However, GDP per capita and energy use enhance its development.

With regards to institutional quality and renewable energy investments and consumption, whereas several studies have been conducted to investigate economic institutions and FDI, few studies have been carried out in the context of renewable energy investments. A study conducted by Marinescu and Fucec (2014) examined the effect of economic freedom on the efficiency of renewable energy investments and inflows in five European countries - Germany, Greece, Switzerland, Romania and Ukraine. They used panel data for the period 1995 to 2011 and based on two linear regression models, established a positive effect of economic freedom on the efficiency of renewable energy investments in the five countries. Other studies have looked at institutions and renewable energy consumption. A recent study by Amoah et al., (2020) find that economic institutional quality indicators such as trade freedom and business freedom increase consumption of renewable energy while property rights and tax burden have no effect. They used panel data for the period 1996 to 2017 for 32 Africa Countries and the Ordinary Least Square techniques. Similarly, Wu and Broadstock (2015) examine the impact of institutions and financial development on renewable energy consumption for the period 1990 to 2010 for 22 emerging countries. They find both institutions and financial development to have a positive effect on renewable energy consumption. Also, Bhattacharya et al., (2017) establish that institutional alignment is crucial to enhance renewable energy consumption across economic activities to ensure sustainable economic growth. They employed the system Generalised Method of Moments (GMM) estimation technique and annual data of 85 countries from 1991 to 2012.

Regarding political institutions and renewable energy consumption and deployment, Dasgupta et al., (2016) analyze how political-economic factors affect renewable energy innovation using an unbalanced panel of 20 OECD countries from 1995 to 2010. They establish that political economy factors ensure the movement of countries towards a greener economy. Likewise, Ergun et al., (2019) investigate the effect of democracy, human development index (HDI), per capita GDP and FDI on renewable energy consumption using the random effects generalized least squares estimation technique. Based on panel data of 21 African countries from 1990 to 2013, they find that FDI increases renewable energy consumption. However, higher GDP per capita and HDI negatively affect renewable energy consumption. Democracy, on the other hand, does not affect renewable energy consumption.

In a gist, a review of the literature reveals that there is scanty literature on renewable energy development and institutional quality in SSA while the little that has been done has not investigated how economic and political institutional quality affects renewable electricity investment in SSA. This provides ample justification for the study.

3. Methodology

3.1. Theoretical framework

This study incorporates institutional quality variables into the flexible accelerator model of investment developed by Blejer and Khan (1985) and further extended by Erden and Holocombe (2005) to account for institutional variables. We adopted the flexible accelerator model because, unlike the rigid accelerator model, it allows investments to vary with other relevant variables instead of output growth only (Shih et al., 2007). Following Erden and Holcombe (ibid), the desired level of capital stock, $\mathrm{K}_{\mathrm{t}}^{*}$, of a country at time t, is assumed to be proportional to the expected output Q as:

$$\mathrm{K}_{\mathrm{t}}^{*} = \alpha \mathrm{Q}_{\mathrm{t}}^{\mathrm{e}} \tag{1}$$

Where α is a constant measuring the elasticity of output with respect to capital assumed constant. We assume that the underlying production function has (technologically) fixed proportions among factor inputs, so that factor prices are excluded in the specification (see Blejer and Khan, 1987). For the model to fit into the accelerator model, $\mathrm{K}_{\mathrm{t}}^{*}$ is allowed to vary with changing economic conditions. Partial adjustment for gross investment is given as:

$$\Delta \mathrm{I}_{\mathrm{t}} = \beta \left(\mathrm{I}_{\mathrm{t}}^{*} - \mathrm{I}_{\mathrm{t}-1}\right) \tag{2}$$

Where I_t^* is the desired level of investment. I_{t-1} is the past level of investment, and β is the coefficient of adjustment, $0 \leq \beta \leq 1$.

According to Erden and Holcombe (2005), the coefficient of adjustment in equation (2) can be expressed as:

$$\beta = b_0 + \frac{1}{(I_t^* - I_{t-1})} \left(\sum b_i X_i\right) \tag{3}$$

Where X_i are factors that affect the coefficient of adjustment including macroeconomic factors, and b_0 is the intercept. Putting equation (3) into equation (2) and rearranging yields:

$$\mathrm{I}_{\mathrm{t}} - \mathrm{I}_{\mathrm{t}-1} = \mathrm{b}_0 \left(\mathrm{I}_{\mathrm{t}}^{*} - \mathrm{I}_{\mathrm{t}-1}\right) + \sum \mathrm{b}_{\mathrm{i}} \mathrm{X}_{\mathrm{i}} \tag{4}$$

where $\Delta \mathrm{I}_{\mathrm{t}} = \mathrm{I}_{\mathrm{t}} - \mathrm{I}_{\mathrm{t}-1}$ Gross investment can be defined as:

$$\mathrm{I}_{\mathrm{t}} = (\mathrm{K}_{\mathrm{t}} - \mathrm{K}_{\mathrm{t}-1}) + \delta \mathrm{K}_{\mathrm{t}-1} \tag{5}$$

Where δ is the depreciation rate of capital stock and I_t is gross investment. Equation (5) can therefore be restated as:

$$I_t = [1 - (1 - \delta)L] K_t \tag{6}$$

Where L is a lag operator, $LK_t = K_{t-1}$ At the steady-state, desired investment can be expressed as:

$$I_t^* = [1 - (1 - \delta)L] K_t^* \tag{7}$$

Inserting equation (1) into equation (7) and assuming that the expected output (Q_t^e) is a linear function of current output (Q_t) gives:

$$I_t^* = [1 - (1 - \delta)L] \alpha Q_t \tag{8}$$

Substituting equation (8) into (4) and solving for I_t yields

$$I_t - I_{t-1} = b_0 \left([1-(1-\delta)L]\alpha Q_t - I_{t-1} \right) + \sum b_i X_I \tag{9}$$

$$I_t = b_0\alpha[1-(1-\delta)L]Q_t + (1-b_0)\, I_{t-1} + \sum b_i X_i \tag{10}$$

Thus X_i (institutional quality variables and macroeconomic variables) are expected to have effects on renewable electricity investment. Institutional quality variables are expected to directly affect renewable electricity investment because they could reduce uncertainty relating to weak enforcement of property rights, and high corruption (Benassy-Quere, 2007) thereby reducing the cost of investment and consequently increasing investment in renewable energy. Secondly, they could have a direct effect on investment in renewable electricity because countries with robust democratic regimes tend to boost investors' confidence and induce investment because investors know that their investment will be protected. Macroeconomic variable such as GDP per capita which measures a country's wealth is expected to impact positively on investment. Higher income countries have higher potential and more resources to foster renewable energy development (Ohler and Fetters, 2014). Cost of capital, on the other hand, is expected to negatively affect investment because investors are unable to expand and retool in a situation of high interest rate thereby reducing the number of projects to be undertaken (Chetty 2004). Change in renewable energy output (Q_t), could positively affect investment in renewable energy. That is, by accelerator principles, as demand goes up, investors tend to increase their investment. Past level of investment (I_{t-1}) associated with delivery, planning and construction, is expected to positively affect current investment because the choice of current investment would depend on the previous year's investment in renewable electricity (Lamont, 2000).

3.2. Empirical model specification

Following Erden and Holcombe (2005), the depreciation rate, is set to zero. In equation (10), the coefficient measuring the accelerator, $b_0\alpha$ is expected to be positive and which measures the long-run response of investment to output growth is assumed to be unity based on Blejer and Khan (1984). X_i is therefore expected to vary with macroeconomic and other factors. As a further extension of the flexible accelerator model, we incorporate political and economic institutional quality as presented in equation (11). We adopted the system GMM strategy proposed by Roodman (2009) and specified the model at levels (11) and first difference (12) equations as follows:

$$Ire_{it} = b_0\Delta Q_{it} + b_1 Einst_{it} + b_2 Pinst_{it} + b_3 Gdp_{it} + b_4 Int_{it} + b_5 I_{it-1} + \varepsilon_{it} \tag{11}$$

$$Ire_{it} - Ire_{it-1} = b_0 \left(\Delta Q_{it} - \Delta Q_{it-1}\right) + b_1 \left(Einst_{it} - Einst_{it-1}\right) + b_2 \left(Pinst_{it} - Pinst_{\ it-1}\right)$$

$$+ \mathrm{b}_3 \left(Gdp_{it} - Gdp_{it-1}\right) + b_4 \left(Int_{it} - Int_{it-1}\right) + b_5 \left(I_{it-1} - I_{it-2}\right) + \varepsilon_{it-1} \tag{12}$$

Where:Ire_{it} is log of investment in installed capacity of renewable energy for generating electricity in country i at time t; ΔQ_{it} is output growth in country i at time t; Einst $_{it}$ is economic institutional quality in country i at time t; Pinst Pit $_{it}$ is political institutional quality in country i at time t; Gdp_{it} is log of GDP per capita in country i at time t; Int t_{it} is log of interest rate in country i at time t; and I_{it-1} is lag of installed capacity of renewable electricity in country i at time t. The model was specified in level and first difference to control for heteroscedasticity.

3.3. Data and variable definition

As discussed, the key data required for estimating equations (11 &12) are renewable electricity installed capacity (proxy for investments), economic institutions, political institutions, GDP per capita and the cost of capital. Table 1 presents the variable definition and summary statistics. The choice of installed capacity as a proxy for investment was because there was no readily available data on renewable electricity investment and it has also been used as a proxy for investment in the literature (see Sisodia and Soares, 2014). Data on the annual installed capacity of renewable energy for electricity generation and renewable energy generation (output) which measures the accelerator effect in SSA was obtained from the IRENA website. Data on the index of the quality of economic institutions were generated with EFI from the Heritage Foundation and Wall Street Journal. These indicators included property rights, freedom from corruption, government spending, fiscal freedom, business freedom, monetary freedom, investment freedom, trade freedom, labour freedom and financial freedom. Each indicator uses a benchmark of 0 to 100, where a score of 100 indicates the highest economic freedom and a score of 0 indicates the lowest economic freedom. We carried out Principal Component Analysis (PCA) (see Appendix 1 for details) to construct the quality of economic institutions index using the first three principal components of the 10 economic institutional quality variables. This is because institutional quality variables are highly correlated, therefore, it is difficult to use them in regression analysis (Globerman and Shapiro, 2002; Daude and Stein, 2007). Data on political institutions such as political rights and civil liberties which measure individual rights and freedom was obtained from Freedom House. Political rights consist of three subcategories- electoral process, political pluralism and participation and functioning of government while civil liberties include freedom of expression and beliefs, associational and organizational rights, rule of law and personal autonomy and individual rights. A score of 1 indicates that countries have the largest degree of freedom and a score of 7 signifies the lowest degree of freedom. The average of political rights and civil liberties indicate if a country is free, partly free or not free. Regarding the political institutional quality variable, the index was developed by finding the average between political rights and civil liberties. We recoded the political rights and civil liberties scores with a score of 1 indicating the lowest degree of freedom and 7 indicating the highest degree of freedom. Data on GDP per capita and the cost of capital were obtained from World Development Indicators (WDI). The data covers 42 countries [1] in SSA for the period 2000 to 2015. Data availability informed the choice of countries and time-period.

3.4. Estimation technique

We employed the two-step system GMM estimation technique developed by Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond (1998) for the following reasons: (i) there is persistence in the outcome variable because the correlation between investment in renewable electricity and its first lag is 0.99 which is higher than the rule of thumb threshold of 0.800 required for establishing persistence. (ii) System-GMM estimator can account for cross-country variations: potential endogeneity via instrumentation: unobserved heterogeneity; and small sample biases from the difference estimator (iii) the number of cross-sections (i.e., 42 countries) is higher than the number of periods for each cross-section (i.e.,15 years).

An important consideration for achieving sound system-GMM estimation is the identification and exclusive restrictions. Following Asongu and NwaChukwu (2016) and Tchamyou and Asongu (2017), all the explanatory variables were treated as predetermined or likely to be endogenous, except lending rate, which was treated as a strictly exogenous variable. This identification technique is in line with a strategy proposed by Roodman (2009) for standard treatment for strict exogenous regressors, and it generates one column per variable with missing not replaced with zero.

Regarding exclusive restrictions, the study argues that the lending rate affects $I_r eit$ exclusively through the suspected endogenous variables. The difference in Hansan Test (DHT) for instrument endogeneity is used to determine the statistical validity of the exclusive restrictions. For exclusive restrictions to hold, the null hypothesis of DHT should not be rejected. The validity of the exclusive restriction is achieved if the null hypothesis of the DHT related to the instrumental variable (IV) (lending rate) is not rejected. This is not different from the procedure for assessing standard IV whereby the failure to reject the null hypothesis of the Sargan Overidentification Restriction (OIR) test is an indication that strictly exogenous variables affect the dependent variable via the endogenous variable mechanism (Asongu and Nwachukwu, 2016).

[1] Madagascar, Niger, Sudan, Rwanda,South Africa, Senegal, Sierra Leone, Nigeria, Namibia, Mozambique, Mali, Mauritania, Mauritius, Comoros, Ethiopia, Gabon, Congo Rep, Djibouti, Equatorial Guinea, Eritrea, Central African Republic, Cape Verde, Cameroon, Burundi, Botswana, Malawi, Angola, Benin, Burkina Faso, Tanzania, Togo, Uganda, DR Congo, Zambia, Zimbabwe, Ghana, Guinea, Ivory Coast ,Kenya, Liberia, Lesotho, Swaziland

Table 1. Variable definition and summary statistics

Variable	Description	Mean	Stand. Dev.	Min	Max
Installed Capacity	Installed capacity of renewable energy for electricity generation measured in Megawatts	89.41	351.71	0.10	3845
Economic Institutional Quality Variables					
Property rights	Provides assessment of a country's legal framework and regulations regarding property rights	32.61	14.12	5.00	75.00
Freedom from Corruption	Captures a country's corruption level	28.92	9.68	10.00	73.00
Fiscal Freedom	Assesses burden imposed by taxes as well as the total level of taxation of a country	72.74	9.62	6.90	92.70
Government Spending	Provides assessment of the burden imposed by government expenditure	74.24	17.99	0.00	99.30
Business Freedom	Assesses limitations imposed by regulatory and infrastructure environment on the efficiency of operation by businesses	52.57	12.88	17.10	85.00
Labour Freedom	Quantitatively assesses a country's labour market laws and regulations	56.36	14.26	21.90	91.40
Monetary Freedom	Captures price stability of a country	71.95	13.14	0.00	90.40
Trade Freedom	Assesses barriers relating to duties and levies on goods and services imported and exported	66.49	10.18	0.00	89.00
Investment Freedom	Measures how regulatory burden impacts on investment	44.40	16.65	0.00	90.00
Financial Freedom	Assesses efficiency of the banking industry in a country as well as financial sector independence	42.58	13.74	10.00	70.00
Political Institutional Quality Variables					
Political Right	Assesses the process of elections and function of government	4.28	1.82	1.00	7.00
Civil Liberties	Assesses the degree of freedom and individual rights	4.04	1.46	1.00	7.00
Other Variables					
Renewable Electricity Generation	Maximum electricity generation from renewable energy measured in gigawatt-hour	160.43	458.91	0.14	5470.63
GDP per Capita	Measures output of a country. It is measured as GDP per capita at constant 2011 US dollars	4645.70	6912.99	543.60	42957.96
Cost of capital/interest rate	Lending rate charged by Banks. It measures cost of borrowing	21.13	47.36	5.57	478.96

Source: Author's Table using data from IRENA, Heritage Foundation, Freedom House and WDI

We first analyse the effect of the individual institutional quality variables on investment in renewable electricity before putting them together to construct an index of institutional quality. Additionally, we carried out a correlation between the institutional quality index and the individual institutional quality variables (see Appendix 2) to identify the variable with significant influence on the index. Three models were estimated. The first model (model 1) involves the dependent variable and the quality of economic institutions index together with the controls. The second model (model 2) involves the dependent variable and the quality of political institutions index together with the controls. The third model (model 3) excludes from the economic institutional quality index all the individual economic institutional quality variables which do not have a significant effect on renewable electricity investment. All the standard errors were corrected for heteroskedasticity and arbitrary patterns of autocorrelation within countries. Also, all the variables are in logarithm except the institutional quality indices.

4. Results and discussions

The results of the effect of the individual economic and political institutional quality indicators are presented in Appendix 3 and that of the economic and political institutional quality index is presented in Table 2. Regarding the individual institutional quality variables, the results revealed that all the individual political and economic institutional quality variables have a significant effect on renewable electricity investment except government spending, monetary freedom and trade freedom. Diagnostic tests were carried out to ascertain the appropriateness of the GMM estimation technique. The models conform to all the information criteria required to establish the validity of GMM. The results show that the AR (2) in the difference for the absence of autocorrelation in residuals cannot be rejected. The Hansen over-identification Restriction (OIR) was not significant, meaning that the instruments are valid and not correlated with the error term. Additionally, the Difference in Hansen Test (DHT) for exogeneity of the instrument indicates that the Hansen OIR test is valid. Thus, the diagnostic tests show that the adoption of GMM estimation was appropriate.

The quality of economic institutions index, lag of installed capacity of renewable electricity, accelerator (renewable electricity output) and GDP positively and significantly affect renewable electricity investment. In the case of model 1, the economic institutional quality index is significant at 10% level while accelerator and GDP are significant at 5% level and 10% respectively. The lag of installed capacity of renewable electricity is significant at 1% and the cost of capital is significant at 10 %. Regarding model 2, the political institutional quality index is significant at 5% while lag of installed capacity of renewable electricity, cost of capital and GDP are significant at 1%.

A unit increase in the quality of economic institutions results in 6% [2] average change in investment in renewable electricity. Higher renewable electricity investment is associated with countries with strong economic institutional quality than countries with weak economic institutional quality when GDP per capita, cost of capital and change in renewable electricity output are controlled for.

Table 2. Two-Step System GMM Estimation of the Impact of Economic and Political Institutional Quality Index on Renewable Electricity Investment

	Model 1	Model 2	Model 3
Lag of installed capacity	$0.78^{***}(0.258)$	$0.48^{***}(0.148)$	$0.77^{**}(0.250)$
Economic institutional quality index	$0.06^{*}(0.033)$		$0.04^{*}(0.024)$
Political Institutional Quality Index		$0.50^{**}(0.235)$	
Log of Cost of capital	$-1.24^{*}(0.710)$	$-2.29^{***}(0.671)$	$-1.337^{*}(0.774)$
Log of GDP per capita	$0.51^{*}(0.297)$	$0.78^{***}(0.206)$	$0.574^{**}(0.282)$
Log of renewable energy output (accelerator)	$0.43^{**}(0.204)$	$0.51^{*}(0.297)$	0.347(0.203)
Arellano-Bond test for A R(1) in first differences, P>Z	0.59	0.68	0.99
Arellano-Bond test for A R(2) in first differences, P>Z	0.40	0.33	0.19
Sargan Test of over-identifying restriction, Prob > chi2	0.47	0.24	0.11
Hansen Test of over-identifying restriction, Prob> chi2	0.39	0.38	0.59
DHT of exogeneity of instrument			
(a) IV (Lendingrate) Hansen test excl. group	0.39	0.35	0.56
Difference (null H= exogenous)	0.29	0.45	0.44
	178	178	178
Number of groups	26	26	26
Number of instruments	26	26	27

Economic institutional quality variables such as property rights (for example, ill-defined property rights may result in a high risk of expropriation which could discourage investment), financial freedom (for example ,inefficient regulation may lead to poor services, high cost and weak investment financing), investment freedom, business freedom, trade freedom (for example, restrictive trade policies may discourage investment by impeding the ability of firms to import inputs and increase their transaction cost, thereby lowering productive efficiency) and freedom from corruption (for example, high level of corruption could results in an environment of mistrust, thus, providing unhealthy business environment) were found to be highly correlated with the economic institutional quality index (Appendix 2). Thus, countries with strong institutional quality variables could increase their investment in renewable electricity. An explanation could be that renewable electricity requires high sunk costs, therefore countries with good economic institutional quality could reduce uncertainty relating to weak enforcement of property rights, and high corruption (Benassy-Quere et al., 2007), thereby reducing the cost of investment and consequently increasing investment in

[2] $(e^{(0.06)} - 1) * 100\%$

renewable electricity. Also, financial and business freedom could reduce transaction costs and allow investors to take opportunities, increase joint ventures (Williamson et al., 2008) and increase investment in renewable electricity. Further, good economic institutional quality -trade freedom, for instance, could foster market exchange by lowering barriers to international trade and minimising regulatory barriers (Erden and Holcombe, 2005) thus increasing investment in renewable electricity.

These findings support studies by Marinescu and Fucec (2014), Bello & Subasat (2012), Ajide & Eregha (2014) who find that economic institutional quality positively and significantly affects the flow of foreign direct investment. As explained by Nasir and Hassan (2011), the location of a business depends on trade openness and low corruption levels because they boost the confidence of investors. The quality of economic institutions plays a significant role in investment in renewable electricity because higher institutional quality protects and enhances market exchange such as protection of property rights, low barriers to international trade, low taxes, and minimizes regulatory barriers which encourage investment in renewable energy.

The political institutional quality index has a positive and significant effect on investment in renewable electricity when other variables were held constant. Specifically, countries that can increase their political and civil liberties by one unit could increase their average installed capacity of renewable energy for electricity generation (investment) by 65% [3]. Therefore, countries with strong political and civil liberties such as freedom of association, freedom of movement, religious freedom, academic freedom, freedom of expression and voting rights are more likely to attract investment in renewable energy than countries with low political and civil liberties.

Studies that lend support to these findings include, Bergara et al., (1998) and Cubbin and Stern (2006). Bergara et al., (ibid) find that countries that can improve their level of political constraints by one standard deviation could increase their electricity generating capacity by 1.2MW per 1000 population while Cubbin and Stern (ibid) concluded that improvements in governance positively and significantly affects electricity generation capacity per capita, though no evidence of the impact of improved governance on electricity transmission and technical losses was observed. The findings differ from that of Erdogdu (2013) who found that civil liberties and political rights negatively affect power reforms.

In a gist, the quality of economic and political institutions are important in explaining investment in renewable electricity as they tend to enhance exchange by reducing costs of transaction, encouraging trust and protecting private property rights for a large section of society with some level of opportunity for those with a good investment opportunity to take advantage.

The coefficient on the lag of renewable electricity investment (three-year lag) is positive and significant indicating that past investment in renewable electricity positively affects current renewable electricity investment. The estimated coefficient of the lagged dependent variable is 0.78 (model 1), implying that actual investment in renewable electricity adjusts to its desired level by 22% within a three-year period. In other words, the gap between actual and desired levels of investment in renewable electricity closes by 22% within a three-year period. Lags associated with delivery, planning and construction could affect the current level such that the choice of current investment would depend on the previous year's investment in renewable electricity (Lamont, 2000).

Regarding the macroeconomic variables, an increase in GDP per capita increases renewable energy investment. That is, higher-income countries have higher potential and more resources to foster renewable electricity development. Countries with higher incomes can handle the cost associated with the development of renewable electricity and are also able to guarantee higher support for the cost of promoting public policies relating to renewable energy (da Silva, 2018). This confirms the findings by Apergis & Payne (2010), Menegaki (2011) and Ohler & Fetters (2014). Sadorsky (2009a) finds that renewable energy consumption per capita is associated with an increase in real GDP per capita in the long run. The results show that cost of capital negatively and significantly affects investment in renewable electricity. That is, an increase in lending rate could reduce investment in renewable electricity. This is because when the cost of capital increases, investors are unable to retool and expand thereby reducing the number of projects to be carried

[3] $(e^{(0.5)} - 1) * 100\%$

out. For instance, Chetty (2004) finds that cost of capital affects investment negatively. He indicated that firms are not able to undertake profitable projects when the cost of capital is high. The coefficient of change in renewable electricity output (accelerator) positively and significantly affects investment. That is, an increase in renewable electricity output raises renewable electricity investment. Thus, investment in renewable energy is mainly to meet an increase in demand for renewable electricity.

We computed the average time lag for investment in renewable electricity to respond to variations in quality economic institutions using the formula proposed by Blejer and Khan (1984). That is (τ/b_i), where τ is the coefficient of lag installed capacity of renewable electricity and b_i is the coefficient of either the economic institutional quality index or political institutional quality index. The average time lag adjustment of renewable electricity investment to variations in economic institutional quality is 13 years. The estimation of the average time lag in the adjustment of investment in renewable electricity to variations in political institutional quality indicates that it takes about one year for adjustment in lag investment to respond to variations in political institutional quality. This finding suggests that countries that do not take their economic and political institution seriously may find it difficult to increase their renewable electricity investment. Poor quality of economic institutions will delay investment in renewable electricity for about 13 years if nothing is done to improve the economic institutions. This is because good economic institutions support physical and human capital development as well as technology and organization of production (Acemoglu et., 2005). The findings corroborate that of Acemoglu et al., (2005) and Weil (2008) who emphasized that economic institutions determine the incentives of the main performers in the economy and the outcome of economic processes such as the distribution of resources.

Macroeconomic factors such as GDP per capita and lending rate are crucial in increasing investment in renewable electricity. Countries in SSA with higher incomes attract more investors, thereby, increasing renewable electricity investment. However, a higher lending rate deters investment because investors find it difficult to retool and expand. The findings also support the accelerator principle which stipulates that demand for investment does not vary with the volume of output but with the acceleration of demand implying that an increase in demand for renewable electricity will result in an expansion of the installed capacity of renewable energy for electricity generation.

5. Conclusion

This paper examines how institutional quality explains investment in renewable electricity in SSA. Using system GMM estimation technique, the study finds that the quality of economic institutions positively and significantly affects renewable electricity investment as a unit increase in the quality of economic institutions results in 6% increase in investment in renewable electricity. Also, it takes 13 years for renewable electricity to respond to changes in economic institutional quality. Similarly, the quality of political institutions affects renewable electricity positively. Specifically, a unit increase in the quality of political institutions leads to 50% increase in the installed capacity of renewable energy for electricity generation. Also, it takes one year for renewable electricity investment to respond to changes in political institutional quality. Furthermore, macroeconomic factors such as GDP per capita and cost of capital are crucial in increasing investment in renewable electricity.

The study recommends that policymakers make an effort towards improving economic institutional quality such as effectively and properly defining property rights and enforcing them, establishing efficient financial regulation to reduce poor service, high cost and weak investment, removal of administrative hurdles, reduction in corruption as well as the removal of ineffective restrictive trade policies to attract more investment into the renewable energy sector. Additionally, countries with low political institutional quality should put in strategies to ensure freedom of expression, freedom of movement and political pluralism through the strengthening of the existing laws and regulations as well as implementing the recommendation of Transparency International on good governance. Finally, governments should pursue policies that promote economic growth as a way of attracting investment in renewable electricity.

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Appendix

Appendix 1: Construction of the PCA

The index of economic institution was computed as:

$$Index1 = ((0.4273 * zpropright) + (0.3100 * zfreedcorrupt) + (0.1941 * zfiscalfreed)$$

+(0.1023 * zgovspending)+(0.3426 * zbusinessfreed)

+(0.2455 * zlaborfreed)+(0.2539 * zmonetaryfreed)

+(0.2930 * ztradefreed)+(0.4033 * zinvestfreed)+0.4273 * zfinfreed)

Index2=((0.1227 * zpropright)-(0.3859 *zfreedcorrupt)+(0.1748 * zfiscalfreed)

+(0.6371 * zgovspending)+(0.2712 *zbusinessfreed)-(0.3469* zlaborfreed)

+(0.4189 *zmonetaryfreed)+(0.1121 * ztradefreed)

+(0.0502 * zinvestfreed)+(0.1227 *zfinfreed)

Index3=(-0.1175 * zpropright)-(0.2301 *zfreedcorrupt)+(0.7690 * zfiscalfreed)

-(0.0043 * zgovspending)-(0.0621 *zbusinessfreed)

+(0.0311 * zlaborfreed)-(0.0311 * zmonetaryfreed)+(0.4474 * ztradefreed)

-(0.0137 * zinvestfreed)-(0.1175 * zfinfreed)

Where zpropright, zfreedcorrupt, zfiscalfreed, zgovespending, zbusinessfreed, zlaborfreed, zmonetaryfreed, ztradefreed, zinvestfreed and zfinfreed are standardize coefficient of The overall quality of economic institutional index was computed by multiplying each index by its variance and dividing the total by the overall variation of the first three principal component. That is:

$$Econsinstituind \quad = ((index1 * 2.48307) + (index2 * 0.382331) + (index3 * 0.339346))/0.6607$$

Where index1 is the index of the first component loadings; index2 is the index of the second component loadings; and index 3 is the index of the third component loadings. The figures in the brackets are the differences (variances) of the first three components (see Table 3).

Table I: PCA for economic institutional quality index (Eigenvalue)

Component	Eigenvalue	Difference	Cumulative
Comp1	3.98515	2.48307	0.3985
Comp2	1.50208	0.382331	0.5487
Comp3	1.11975	0.339346	0.6607
Comp4	0.780404	0.145361	0.7387
Comp5	0.635043	0.0610405	0.8022
Comp6	0.574002	0.119232	0.8596
Comp7	0.45477	0.0752639	0.9051
Comp8	0.379506	0.0548698	0.9431
Comp9	0.324636	0.0799774	0.9755
Comp10	0.244659		1

Source: Author's computation using Heritage Foundation's economic freedom rating

Table II: Component Loadings of Economic Institution Variables

Variable	Comp1	Comp2	Comp3	Unexplained
Property rights	0.405	-0.1196	-0.2908	0.2302
Freedom from corruption	0.3553	-0.3461	-0.1913	0.2761
Fiscal freedom	0.1747	0.2691	0.6747	0.2599
Government spending	0.0771	0.6665	-0.099	0.298
Business freedom	0.3793	-0.2000	-0.0341	0.3652
Labour freedom	0.2474	-0.2761	0.2205	0.587
Monetary freedom	0.2476	0.4458	-0.3586	0.3132
Trade freedom	0.2913	0.0075	0.4837	0.3996
Investment freedom	0.4116	0.1243	-0.0076	0.3017
Financial freedom	0.3906	0.1368	-0.0389	0.3621

Source: Author's computation using Heritage Foundation's economic freedom rating

Appendix 2: Correlation between individual institutional quality variables and institutional quality index

Institutional Quality Variable	Economic Institutional Quality Index
Property Rights	0.77
Freedom from Corruption	0.65
Fiscal Freedom	0.43
Government Spending	0.22
Business Freedom	0.73
Labour Freedom	0.48
Monetary Freedom	0.51
Trade Freedom	0.62
Investment Freedom	0.83
Financial Freedom	0.78
	Political Institutional Quality Index
Political Rights	0.60
Civil Liberties	0.15