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Foreign direct investment and Renewable energy developmentin sub-Saharan Africa: Does governance quality matter?

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Foreign direct investment and Renewable energy developmentin sub-Saharan Africa: Does governance quality matter?

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Abstract

Existing studies have been separated, considering the foreign direct investment (FDI) and renewable energy development (RE) nexus and the governance quality- renewable energy development relationship. However, the study regarding the moderation of governance quality on the FDI-renewable energy nexus is quite scarce. To fill the gap in the literature, the study therefore examines the moderation of governance quality on the influence of FDI on (RE) in 37 sub-Saharan African economies over the period 1996-2020. To achieve this goal, the panel corrected standard errors (PCSE) estimation technique has been adopted. The results show that FDI has a positive and significant effect on RE, meaning that an increase in foreign direct investment could lead to a 0.05 increase in RE. Moreover, the results unveil that governance quality is positively and significantly associated with RE. This means that a unit increase in control of corruption, governance effectiveness, rule of law, and voice and accountability leads to a 9.64, 9.10, 10.10 and 9.08 increase unit in the renewable energy sector, respectively. Most importantly, the results indicate that the interaction between FDI and governance quality has a positive and significant effect on RE. Policy implications are discussed based on the findings revealed by this study.

Keywords: Foreign direct investment, governance quality, renewable energy development, sub-Sharan Africa

1.Introduction

De-carbonization of energy sources through promotion of renewable energy consumption are critically important to meet sustainable development goals (SDGs). In recent years, renewable energy has been found as the surest way to curb CO_2 emissions and promote environmental sustainability(Ali et al., 2022; Dimnwobi et al., 2022; Khan et al., 2021; Papież et al., 2018). For example, using 43 most resource-dependent countries from 2000 to 2015, Szetela et al. (2022) examined the drivers of CO_2 emissions and found that renewable energy seems to curb CO_2 emissions, which by extension, could contribute to the promotion of environmental sustainability. Similar conclusion was reached by Saidi Omri (2020)who concluded that promoting renewable energy could contribute to lessening CO_2 emissions. Recently, Doytch and Narayan (2021) have pointed out the positive effect of renewable energy on socio-economic development. Pointing out the positive effect of renewable energy on the achievement of SDGs, it is imperative to investigate the determinants of renewable energy in sub-Saharan Africa where the study regarding the drivers of renewable energy is very sparse.

The fulcrum in which renewable energy can be developed is foreign direct investment. It has been documented that the renewable energy sector can be financed by external sources of finance which are, foreign aid, remittances, and foreign direct investment(Fotio et al., 2022). Recently, it has been noticed that sustainable energy investment is required to boost the renewable energy sector and promote sustainable environment. Attracting foreign direct investment in the renewable energysector is expected to strengthen innovation capacity in the subsidiary(Doytch & Narayan, 2015). Moreover, it has been argued that attracting foreign direct investment in the renewable energy sector could contribute to the greening of the knowledge based on the headquarter of the multi-technology conglomerates.Although there are few studies on the relationship between foreign direct invetsment and renewable energy consumption(Mahbub et al., 2022), the study regarding sub-Saharan Africa remains very scanty, according to our knowldege.

In the meantime, it has been documented that the investment in the renewable energy sector depends on the quality of governance or institutions of a country(BELAÏD et al., 2021). As defined by North (1990), institutions are considered as the rules which regulate the society and human interactions. Good institutions have recently been

documented as major drivers of economic growth (Acemoglu et al., 2004; Dossou et al., 2021; Nguyen et al., 2018; Shahzad et al., 2022). According to Acemoglu et al., 2004, countries with good insistutions are expected to experience higher economic growth. Recently, Raza et al. (2021) noted that countries with good institutions are expected to attract more foreign direct investment, which by extension could contribute to expediting economic growth. Very recently, It has been argued that good institutions can contribute to attract more foreign direct investment and promote renewable energy development. For example, Doytch and Narayan (2016) argued that countries with good governance could contribute to increase the level of stability, which plays a significant role in attracting foreign direct investment, which by extension could contribute to enhancing renewable energy development through technological transfer. Similarly, it has been documented that lowering corruption could contribute to increasing confidence of foreign investors who can invest more in renewable energy (Zhang & Zhang, 2022). Likewise, Sou and Vinnicombe (2021) posited that countries with higher governance effectiveness are expected to protect property right, which could contribute to the betterment of cooperation between domestic investment and foreign investment, which by extension can spur renewable energy development. In the same vein, political stability has been identified as major prequisite to the attractiveness of foreign direct investment, which by extension, could develop promising renewable energy technologies(BELAÏD et al., 2021).Confirming this fact, Pan et al. (2022) argued that institutional improvement seems to promote renewable energy development through attracting foreign direct investment. It has alsobeenargued that quality of institutions or good governance can postively affect green foreign direct investment through reducing transaction costs and risk (World Economic Forum 2021). Despite these arguments, the study on the moderation of governance quality on the foreign direct investment-renewable energy development nexus is quite inexistent. Thus, exploring the moderation of governance quality on the effect of foreign direct investment on renewable energy development in Sub-saharan Africa is critical to guide Sub-saharan Africa policy makers to rethink the issues of energy security in the region.

Sub-saharan Africa has been pointed out as an appropriate context to assess the moderation of governance quality on the foreign direct investment-renewable energy development nexus for at least four reasons. First, it is important to emphasize that sub-Saharan Africa still relies on traditional biomass, namely wood and charcoal, which

account for 66% of total final energy consumption region-wide (International Energy Agency, 2020). Despite its huge potential in renewable energy, which has not been yet utilized, renewables accounted for only 7% of the total primary energy supply, 8% of total final energy consumption and 26% of power generation in the region as of 2018 (IRENA, 2020). Considering the above fact, itis imperative to promote renewable energy development in sub-Saharan Africa.

Second,Sub-saharan Africa has witnessed an increase in foreign direct investment in recent years. According to Beri and Nubong (2021), foreign direct investment inflows have grown by 3.34% from 2008 to 2018. However, it is low compared to Asia and Latin America (Xu et al., 2021). Third, while good quality of institutions or governance plays a significant role in enhancing or propelling economic growth, the quality of governance in Sub-saharan Africais relatively poor(Ouedraogo et al., 2021). As shown in Figure 1, the mean value of all governance indicators are negative. Fourth, the energy economics literature in Sub-saharan Africa has largely ignored the study regarding the moderation of governance quality on the foreign direct investment-renewable energy deployment nexus.
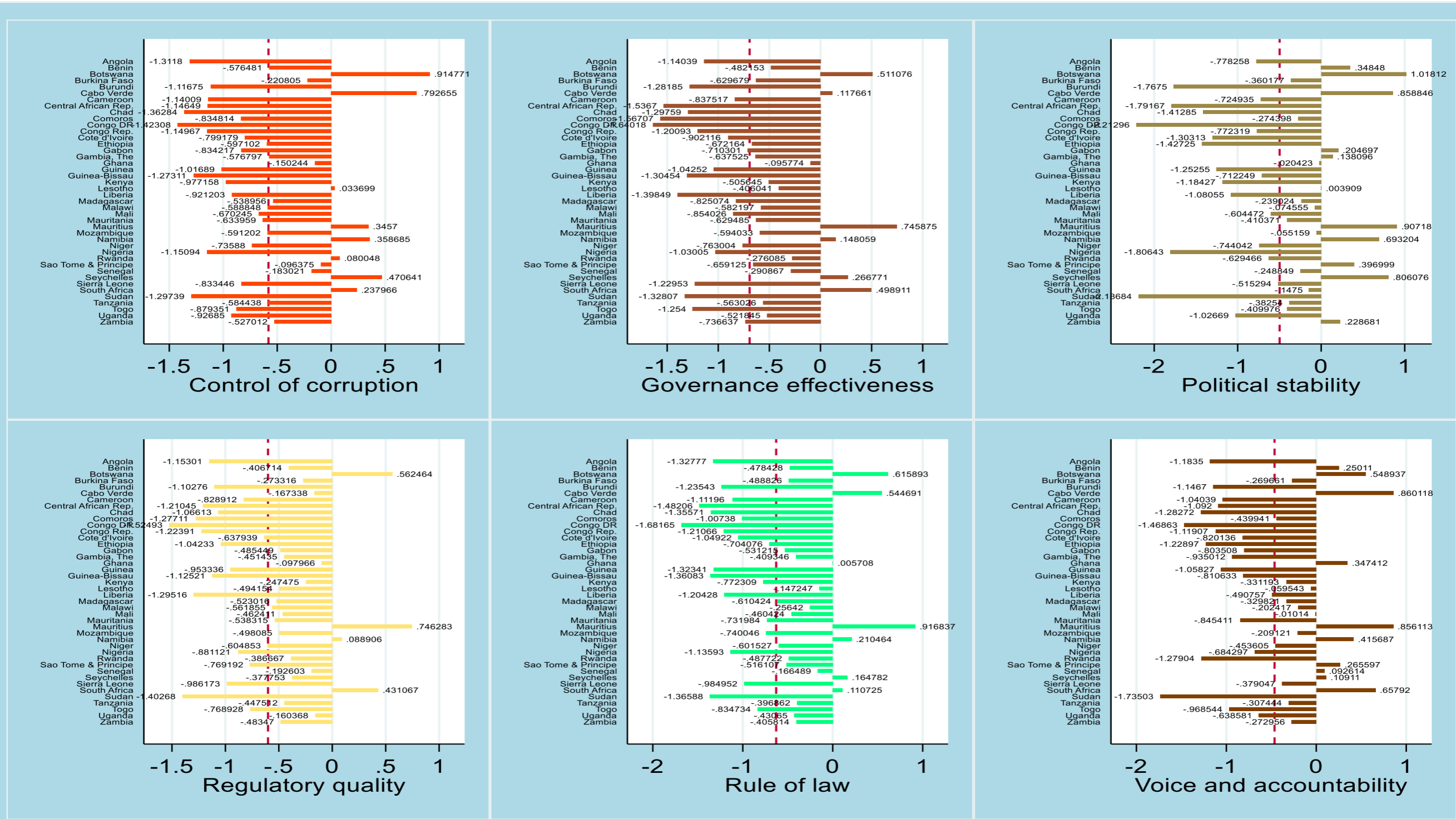
Figure 1: Average Within Country governance quality in Africa, 1996-2020

Source: Authors' calculation from World Bank Governance Indicators (WGIs) database.

The contributions of this study are twofold. First, this study is the first to empirically assess the relationship between foreign direct investment and renewable energy deployment in 37 Sub-saharan African economies over the period 1996-2020. As we mentioned above, the study regarding the relationship between foreign direct investment and renewable energy consumption is rare in sub-Saharan Africa. As argued by Khan et al. (2021), developing countries are subject to many challenges such as financial challenge, technical innovation challenge, social and legal challenge, and the only way to overcome these challenges and promote renewable energy deployment is to attract foreign direct investment, which plays a significant role in achieving the SDGs. Second, this study extends the energy economics literature by examining the moderating effect of governance quality on the relationship between foreign direct investment and renewable energy consumption as it is rare in the energy economics literature. As we mentioned, four policy implements have been provided to attract foreign direct investment in the renewable energy sector.

The rest of the paper is organized as follows. Section 2 reviews previous studies. Section 3 describes data, methodology, and model specification. The empirical results and discussion are presented in Section 4, before concluding the paper in Section 5.

2. Literature review

This section is discussed in two main strands, especially as it pertains to the theoeretical and empirical literature. Accordingly, the first strand is concerned with the theoretical nexuses between foreign direct investment, governance quality and renewable energy development while the second strand is concerned with empirical studies, especially as it relates to two main linkages, notably: empirical studies on the nexus between foreign direct investment and renewable energy on the one hand and on the other, the linkage between governance quality and reneweable energy. These strands are expanded in the same chronology as highlighted.

In the first strand on theoretical studies, the new growth theory has been pointed out as an important mechanism that could explain the relationship between foreign direct investment and clean energy. New growth theory suggests that there will be interaction between developing and developed countries in terms of knowledge spillover (Romer, P. M., 1994). During such process, foreign direct investment is expected to be benefited by developing economies. Foreign direct investment is expected to expedite economic

growth and improve environmental quality through technological transfer (Adams, 2008). As argued by Sarkodie et al. (2020), foreign direct investment comes from developed countries where environmental policies are strict and they bring high technology, which could contribute to promote green energy by improving energy efficiency. The Pollution Halo theory suggests that foreign direct investment is regarded as an important tool to promote economic growth through improving technological innovation.

Regulatory risk and political risk are the two mechanisms which explain the linkage between governance quality and renewable energy. Regulatory risk remains an important tool for foreign investors to invest in the renewable energy sector (Bellakhal et al. 2019). According to the author, reducing regulatory risk could contribute to attracting foreign investors who will promote renewable energy investment. Similarly, reducing political risk could contribute to attracting foreign direct investment in the renewable energy sector.

In the second strand on empirical studies, two main empirical perspectives are provided, especially as it pertains to the studies linking foreign direct investment and renewable energy (i.e. first perspective) and research within the remit of governance and renewable energy (i.e. second perspective). The empirical perspectives are expanded in the same chronology as highlighted. As concerns the first empirical perspective, a study by Brunnschweiler (2010) posited that a large amount of technology, which can be found from external source of finance (foreign direct investment) is required to promote renewable energy development. In the same spirit, Wall et al. (2018) documented that green jobs can be created because of the positive effect of green foreign direct investment on the renewable energy sector. In the same account, innovation is another channel through which green foreign direct investment can promote renewable energy development. In the same vein, Amendolagine et al. (2021) argued that green foreign direct investment could contribute to improving energy security and enchance green growth through promoting competeveness. A study by BELAÏD et al. (2021) used 9 selected MENA countries as a case study to examine the influence of foreign direct invetsment on renewable energy development over the period 1984-2014. The results of fixed and random effect show that foreign direct investment appears to promote renewable energy development.

Although several studies in African countries have related international openness through investment to energy consumption from the general context, extensive analyses which examine the dynamics from renewable energy perspective is still scarce (Aïssa, et al. 2014; Ergun, 2019).Ben Aïssa et al. (2014) also showed that there is long-run causality running from international openness to renewable energy consumption in Africa. Similarly, the relationship between foreign direct invetsment and renewable energy development has been examined by Ergun et al. (2019) who used 21 African countries as a case study. The results of fixed and random effects show that foreign direct invetsment has a positive impact on renewable energy development.

Looking at the second empirical perspective (i.e. studies on the nexus between governance quality and renewable energy), it has been argued that governance quality plays a significant role in promoting renewable energy development in both developed and developing countries (Pan et al., 2022). Acknowledging the crucial role of governance quality, many scholars have examined the relationship between governance quality and renewable energy development. For instance,BELAÏD et al. (2021) revealed that the improvement of governance quality in MENA countries could contribute to promote renewabele energy development. Further, a study by Awijen et al. (2022) used the panel threshold regression (PTR) model to examine the impact of governance quality on renewable energy development in 9 MENA countries over the period 1984-2014. They found that renewable energy development cannot be achieved in the absence of good governance.

Although the relationship between governance quality and renewable energy development has been studied in recent years in other continents, the study regarding the case of Africa is rare. Recent exceptions include Pan et al. (2022) who used the panel corrected standard errors (PCSE) estimation technique to assess the impact of governance quality on renewable energy development for a panel of 42 African countries. Unfortunately, they found a negative relationship between governance quality and renbewable energy development. According to the authors, this fact can be explained as sub-Saharan African governments still promote non-renewable energy development.

The existing studies have separately investigated the foreign direct investment-renewable energy development nexus and governance quality-renewable energy development relationship in developing countries which have so far been largely ignored sub-Saharan Africa. Moreover, an empirical examinationof the moderation of governance quality on the foreign direct investment-renewable energy development nexus has been largely ignored.Therefore, this study addresses the moderating impact of governance quality on the relationship between foreign direct investment and renewable energy development in sub-Saharan Africa using the panel corrected standard errors (PCSE) estimation techniques. The findings will contribute to expanding the energy economics literature and will help sub-saharan Africa to improve its energy security and achieve the SDGs by 2030.

3. Methodology

3.1 Model specification

To examine the influence of foreign direct investment on renewable energy development, we followed a study by Awijen et al. (2022) who have examined the drivers of renewable energy development in MENA countries. Thus, our model can be written as follows:

$$REN_{it} = \alpha_0 + \alpha_1 TOP_{it} + \alpha_2 GDP_{it} + \alpha_3 ICT_{it} + \alpha_4 FD_{it} + \varepsilon_{it} \quad (1)$$

Where: REN=renewable energy development (proxied by renewable energy consumption and alternatively renewable electricity output); TOP=trade openness which is the sum of export and import divide by GDP; GDP=gross domestic per capita (in 2010 constant USD); ICT=information and communication technology which is ICT infrastructure; FD=financial development which is financial institutions development; i=country; t=time; and ε_{it} =error term.

First, this study aims to examine the impact of foreign direct invetsment and governance quality on renewable energy development. Thus, the baseline (equation 1) can be extended as follows:

$$REN_{it} = \alpha_0 + \alpha_1 TOP_{it} + \alpha_2 GDP_{it} + \alpha_3 ICT_{it} + \alpha_4 FD_{it} + \alpha_5 FDI_{it} + \alpha_6 GOV_{it} + \varepsilon_{it} \quad (2)$$

Where: FDI=foreign direct investment which is foreign direct investment as a percentage of GDP; GOV=governance quality which is control of corruption,

government effectiveness, rule of law, regulatory quality, political stability, and voice and accountability.

Second, to capture the moderating effect of governance quality on the relationship between foreign direct investment and renewable development, the equation 1 can be extended as follows:

$$REN_{it} = \alpha_0 + \alpha_1 TOP_{it} + \alpha_2 GDP_{it} + \alpha_3 ICT_{it} + \alpha_4 FD_{it} + \alpha_5 FDI_{it} + \alpha_6 GOV_{it} + \alpha_7 (GOV \times FDI)_{it} + \varepsilon_{it}$$
(3)

Where: $GOV \times FDI$ = the interaction between foreign direct investment and governance quality.

Following a study by Ofori et al. (2021) and Ofori and Asongu (2021), the net effect of foreign direct investment on renewable energy can be computed as follows:

$$\frac{\partial REN}{\partial FDI} = \alpha_5 + \alpha_7 \overline{GOV} \qquad (4)$$

Where: $\overline{GOV}$ = the mean value of governance quality.

3.2 Data

This study focuses on the panel of 37 Sub-Saharan Africa countries[1] over the period 1996-2020. The scope of this study has been considered due to the missing data in the sub-Saharan Africa context.

- *Dependent variable*

Renewable energy development: Following a study by Li et al. (2021); Qin et al. (2021) and Murshed et al. (2020), we use renewable energy consumption and renewable electricity output as a proxy of renewable development. The data on renewable energy development and renewable electricity output has been extracted from the World Development   Indicators

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[1] The countries include: Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Congo, Dem. Rep., Congo, Rep., Cote d'Ivoire, Ethiopia, Gabon, Ghana, Guinea, Kenya, Lesotho, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Seychelles, Sierra Leone, South Africa, Sudan, Sao Tome and Principe, Tanzania, Togo, Uganda, Zambia

(WDIs)(https://data.worldbank.org/indicator/EG.FEC.RNEW.ZS and https://data.worldbank.org/indicator/EG.ELC.RNEW.ZS).

- *Explanatory variables*

Foreign direct investment: In accordance with FDI-clean energy literature, we use foreign direct investment inflows as percentage of GDP. The data on foreign direct investment has been collected from the World Development Indicators (WDIs) of the World Bank.

Governance quality: Following a study by Ramirez (2021) and Simionescu et al.(2021), we use six governance indicators, namely, rule of law, control of corruption, governance effectiveness, voice and accountability, regulatory quality and political stability. The data on governance indicators has been emanated from the World Governance Indicators (WGIs) of the World Bank (https://databank.worldbank.org/source/worldwide-governance-indicators).

- *Control variables*

Financial development: Theoretically, financial development has been seen as an important tool to accelerate economic growth and development in both developed and developing countries (Samour et al., 2022). Recently, financial development has been found to play a significant role in promoting renewable energy development (Mukhtarov et al., 2020). Therefore, an increase in financial development could induce renewable energy development. The data on financial development has been collected from international monetary fund (https://www.imf.org/en/Data).

Economic growth: Renewable energy is seen to promote human well-being and overall welfare. However, recent studies have found a causal relationship between economic growth and renewable energy(Fareed & Pata, 2022; Tsaurai & Ngcobo, 2020). Therefore, an increase in economic growth could induce energy renewable development. The data on per capita GDP has been collected from the World Development Indicators (WDIs) of the World Bank (https://data.worldbank.org/indicator/NY.GDP.PCAP.CD).

Trade openness: Trade openness has been regarded as important tool to expedite economic growth (Xu et al., 2021). Very recently, trade openness has been found to play a significant role in enhancing clean energy (Murshed, 2021). According to Xu et

al. (2022), trade openness could contribute to bringing advanced technologies and knowledge, which by extension could contribute to promote renewable energy development. Hence, an increase in trade openness could leadtoan increase in renewable development. The data on trade openness has been obtained from the World Development Indicators (WDIs) of the World Bank (https://data.worldbank.org/indicator/NE.TRD.GNFS.ZS).

Information technology: In recent years, information technology has played a significant role in enhancing economic growth (Appiah-Otoo & Song, 2021). It has been pointed that, information technology are surest ways to promote clean energy through promoting innovation, reducing information costs and risks (Awijen et al., 2022). Therefore, an increase in information technology could induce promoting clean energy. The data on information technology has been gleaned from the African Development Bank (https://www.afdb.org/en/knowledge/statistics).

3.3 Econometrics Steps

To unearth the moderation of governance quality on the foreign direct investment-renewable energy development nexus, we firstly begin by examining the cross-sectional dependency. To achieve this goal, we use Pesaren's CD test (Pesaran, 2004). As shown in Table A1, all variables are significant, meaning that there is the existence of cross-sectional dependence among the used sample. According to Dossou et al. (2021), the presence of cross sectional dependence among the used sample requires the unit root test. Therefore, we examine the integration properties of the variables in the model using Pesaran (2007). As shown in Table A2, all variables are significant at level, meaning that our panel contains unit root. Moreover, this study examines the cointegration relation between the adopted variable using Kao (1999). As shown in Table A3, the estimated results show a cointegration relationship among the variables. This study has used the panel corrected standard errors (PCSE) estimation techniques developed by Jönsson (2005) which account for cross sectional dependency. Moreover, for the robusteness check, we use the full modify ordinary least square (FMOLS) estimation technique to account for co-integration. To accomplish the estimation procedure, Stata 15 has been used in this study.

4. Results and discussion

4.1 Descriptive statistics and correlation matrix

Tables 1 and 2 show the descriptive statistics and correlation matrix, respectively. As shown in Table 1, the mean value of renewable energy consumption and renewable electricity output is 54.581%of final energy consumption and 37.299%of electricity output respectively. It shows that renewable energy development still remains low compared to other developing countries such as Asia and Latin America (Global Data's FDI Projects Database). Burundi and Congo, Dem. Rep seem to record the highest value, while Seychelles appears to register the lowest value (see Figures 3 and 4). Also, the Table 1 shows that the mean value of foreign direct invetsment is 4.07% of GDP which remains relatively low compared to Asia and Latin America(Xu et al., 2021). Moreover, the mean value of governance quality (control of corruption, governance effectiveness, political stability, regulatory quality, rule of law, voice and accountability) is -0.58, -0.69, -0.49, -0.60, -0.63, -0.46 respectively.

Table 1. Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Dependent variable					
Renewableenergyconsumption	1050	54.581	35.52	0	98.34
Renewableelectricity output	1050	37.29	39.34	0	100
Explanatory variable					
Control of corruption	882	-0.58	0.62	-1.722	1.22
Governance effectiveness	882	-0.69	0.61	-1.88	1.06
Political stability	882	-0.49	0.92	-2.84	1.28
Regulatory quality	882	-0.60	0.55	-2.29	1.13
Rule of law	882	-0.63	0.63	-2.13	1.08
Voice and accountability	882	-0.46	0.68	-1.86	1.01
Foreign direct investment	1050	4.07	7.77	-11.62	103.34
Control variables					
GDP per capita	1050	1696.72	2467.83	0	16390.83
Trade openness	957	68.74	36.75	9.96	311.35
Financial development	967	0.09	0.13	0	0.78
Information technology	756	49.17	26.59	0	99.79

Table 2 shows the correlation matrix. As shown in Table 2, there is positive correlation between foreign direct investment and renewable energy. This means that foreign direct investment might promote clean energy. Moreover, the estimated result shows a positive correlation between governance quality and renewable energy. This means that governance quality might play a significant role in promoting clean energy.
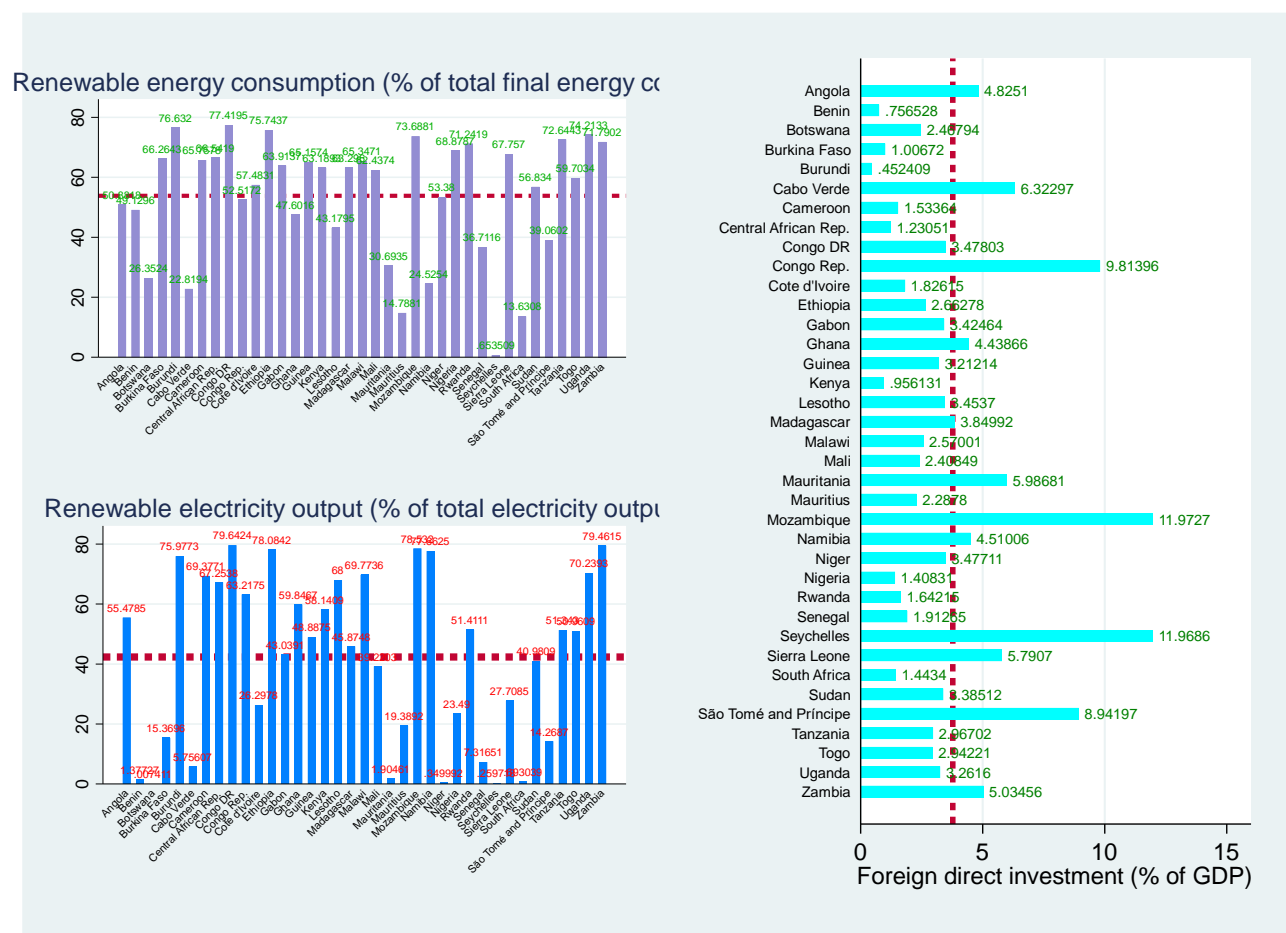

Figure 2. Average Within Country renewable energy and foreign direct investment in Africa, 1996-2020

Source: Authors' calculation from World Bank Development Indicators (WDIs) database.
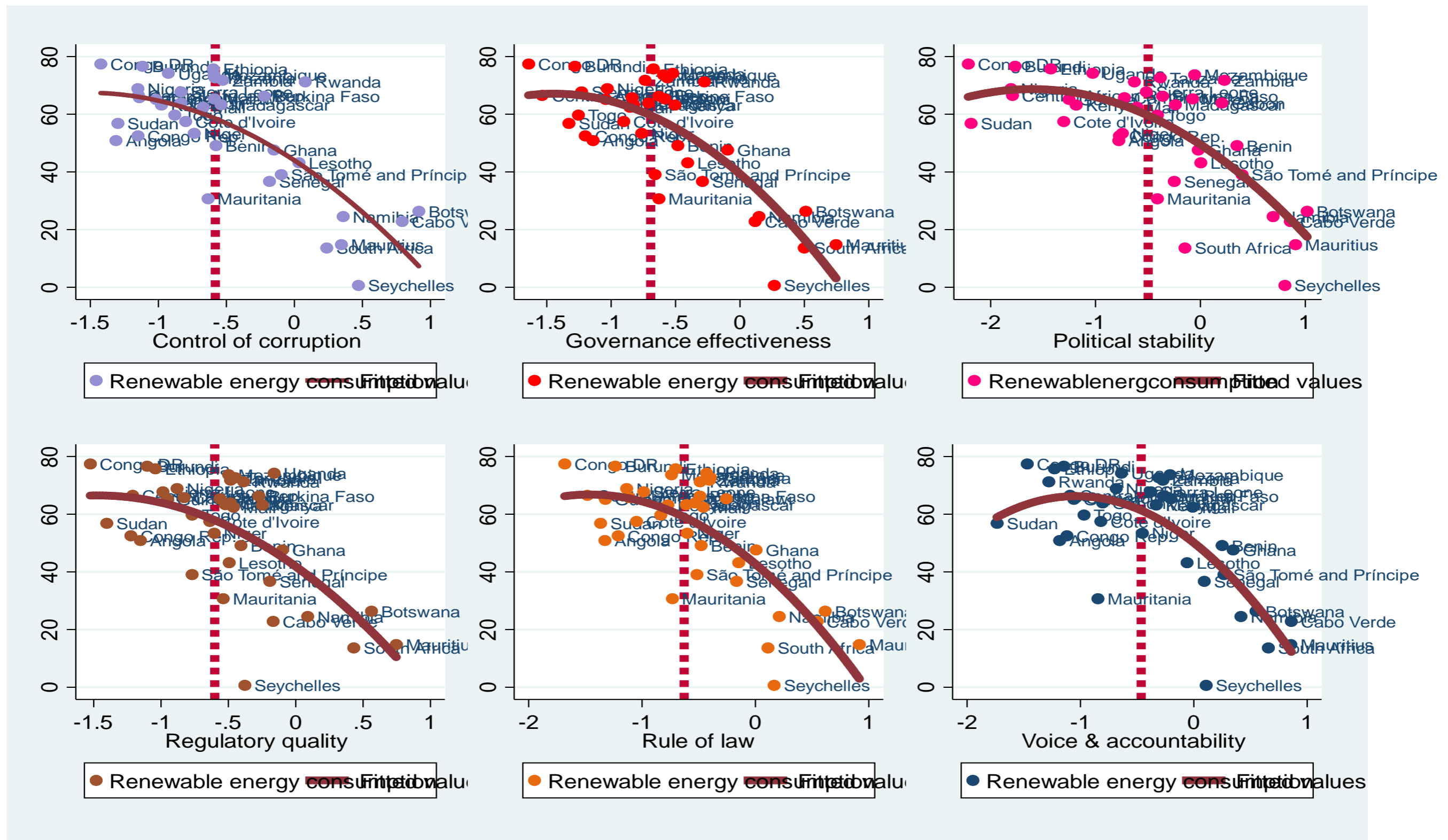
Figure 3. the nexus between renewable energy and governance quality in Africa, 1996-2020

Source: Authors' calculation from World Bank Development Indicators (WDI) database.

Table 2. Correlation matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13
Renewable energy consumption	1												
Renewable electricity output	0.69***	1											
Foreign direct investment	0.08	0.03	1										
Control of corruption	0.40***	0.31***	0.08	1									
Governance effectiveness	0.41***	0.32***	0.03	0.88***	1								
Political stability	0.29***	0.19***	0.16***	0.75***	0.73***	1							
Regulatory quality	0.33***	0.30***	-0.05	0.80***	0.90***	0.69***	1						
Rule of law	0.41***	0.32***	0.03	0.90***	0.93***	0.80***	0.89***	1					
Voice and accountability	0.37***	0.29***	0.03	0.76***	0.79***	0.74***	0.80***	0.85***	1				
Per capita GDP	0.44***	0.29***	0.14**	0.49***	0.59***	0.52***	0.45***	0.53***	0.39***	1			
Trade openness	0.35***	0.05	0.45***	0.41***	0.33***	0.49***	0.19***	0.34***	0.30***	0.61***	1		
Information technology	0.41***	0.29***	0.06	0.39***	0.47***	0.34***	0.46***	0.44***	0.32***	0.60***	0.39***	1	
Financial development	0.48***	0.28***	0.23***	0.61***	0.58***	0.52***	0.39***	0.58***	0.48***	0.77***	0.66***	0.38***	1

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

4.2 The PCSE results

The PCSE results on the combined effect of governance quality and foreign direct investment on renewable energy are displayed in Table 3. Considering the Column 1 of Table 3, the result unveils that the impact of trade openness on renewable energy is positive and statistically significant, meaning that promoting international trade is associated with a 0.0999 percent in renewable energy consumption. This corroborates the argument of Zhao et al.(2020), who argued that the interaction between developed and developing countries in terms of trade could help developing economies through promoting technological transfer importations of advanced machineries which will contribute to promote renewable energy development or clean energy. Similar argument has been given by Lu et al. (2022), who argued that technological transfer could stem from the bilateral trade which is expected to play significant role in promoting renewable energy development.

The results unveil that economic growth is positively and significantly associated with renewable energy. This means that an increase in economic growth could lead to a 0.00240 increase inrenewable energy consumption. This finding aligns with Marques and Fuinhas (2012), who documented that an increase in economic growth could lead to an increase in infrastructural development, which by extension could contribute to enhancing renewable energy development. Our finding supports the argument of Xu et al. (2022) and Ehigiamusoe (2020) who argued that the improvement of economic growth could contribute to promote education which will play a significant role in the attainment of the SDGs by 2030. As argued by Zhang et al. (2022) andZafar et al. (2022), the SDGs cannot be achieved without good education.

The result also indicates that financial development seems to have a positive and significant effect on renewable energy development. This means that a unit increase in financial development could induce a 34.69 unit increase in renewable energy consumption. This finding is consistent with the findings of Oğuz and İskenderoğlu (2022), who argued that the improvement of bank system could contribute to spur renewable energy development.

Similarly, the results show that ICT infrastructure which is used as proxy for information and communication technology has a positive and significant impact on renewable energy development, meaning that an increase in information technology

could induce a 0.278 increase in renewable energy consumption. This corroborates the findings of Awijen et al. (2022) who posited that information technology can positively affect renewable energy through innovation.

First, we consider our first hypothesis by examining the influence of foreign direct investment and governance quality on renewable energy consumption (see Column 1-7). The results show that foreign direct investment appears to have a positive and significant impact on renewable energy. This means that an increase in foreign direct investment could induce a 0.0493 increase in renewable energy consumption. Our finding is consistent with the findings of Awijen et al. (2022) who argued that foreign direct investment has been pointed as a potential tool to promote renewable energy development through innovation. Our finding are consistent with Doytch and Narayan (2016) who documented that foreign direct investment could induce renewable energy through promoting technological transfer which by extension could promote start-up. Similar conculsion was reached by Ali et al. (2022) who argued that green foreign direct investment could induce renewable energy development through several channels, namely technology transfer, technology spillover, innovation, green jobs, and green growth. Our findings are consistent with Ergun et al. (2019) for 21 African countries over the period 1990-2013. However, our finding disagreed with Oğuz and İskenderoğlu (2022) who found an insignificant influence of foreign direct investment on renewable energy for a panel of 23 developed economies. The lack of consensus among previous studies could be ascribed to the use of different variables of renewable energy, sample period, and methodology shortcomings namely cross-sectional dependence, endogeneity, autocorrelation and heterogeneity.

Similarly, the influence of governance quality on renewable energy is positive and statistically significant. This means that a unit increase in control of corruption, government effectiveness, rule of law, and voice and accountability results in a 9.638, 9.105, 10.10 and 9.081 unit increase in the renewable energy sector, respectively. This corroborates the findings of Bellakhal et al. (2019) who argued that reducing corruption could contribute to increasing renewable energy investment. Similarly, our finding is consistent with the results of Yang and Park (2020)and Bellakhal et al. (2019) who argued that promoting security could contribute to increase renewable energy investment in 98 developing countries over the period 2000-2014. Likewise, our finding is in line with the argument of Ofori et al. (2022) who postulated that good

governance matters for the achievement of the SDGs by 2030. Similar results were reached by Ali et al. (2022) who doucumented that good quality of governance could positively affect renewable energy consumption via improvingrenewable portfolio standard (RPS), feed-in tariff (FIT), fiscal measure (FM) or tax incentives, and emission trading schemes (ETS). However, our finding contradicts the results of Pan et al. (2022) who used 42 sub-Sahran African countries over the period 1996-2020 to explore the relationship between governance quality and renewable energy development and found that governance quality has a negative impact on renewable energy energy development.

Second, we consider our second hypothesis by investigating the moderation of governance quality on the foreign direct investment-renewable energy consumption nexus (see Column 8-13). The results show that the interaction between foreign direct investment and governance quality seems to have a positive and significant effect on renewable energy consumption. This means that improving governance quality is important to attract foreign investment in the renewable energy sector. As argued by Masron and Nor (2013) good governance through reducing corruption could positively contribute to provide confidence for foreign investors to invest in the renewable sector, which by extension could contribute to improving job opportunities, wages, social welfare and reducing income inequality and poverty. As this study focuses on the moderation of governance quality on the foreign direct investment-renewable energy consumption nexus, we compute the net effect as follows:

Considering Column [11], the net effect can be calculated as follows:

$$\frac{\partial REN}{\partial FDI} = \alpha_5 + \alpha_7 \overline{GOV} \quad = [0.458 + (0.012 \times -0.601)] = 0.451$$

Where: 0.458 represents the unconditional effect of foreign direct investment on renewable energy; 0.012 denotes the conditional impact of foreign direct investment on renewable energy; -0.601is the average value of regulatory quality.

Considering Column [13], the net effect can be calculated as follows:

$$\frac{\partial REN}{\partial FDI} = \alpha_5 + \alpha_7 \overline{GOV} \quad = [0.135 + (0.016 \times -0.464)] = 0.127$$

Where: 0.135 reflects the unconditional effect of foreign direct investment on renewable energy; 0.016 is the conditional impact of foreign direct investment on renewable energy; -0.464 is the average value of voice &accountability.

Table 3. The PCSE results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Trade openness	0.10**	0.08*	0.11**	0.09*	0.11*	0.11**	0.09*	0.08	0.12*	0.09*	0.12*	0.11*	0.09*
	(0.05)	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.06)	(0.05)	(0.05)
GDP per capita	0.00240***	0.00189***	0.00158***	0.00237***	0.00214***	0.00171***	0.00203***	0.00184***	0.00147***	0.00223***	0.00217***	0.00163***	0.00206***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Information technology	0.28***	0.26**	0.25**	0.28**	0.25*	0.24**	0.26**	0.26**	0.25**	0.29**	0.24*	0.25**	0.25**
	(0.09)	(0.09)	(0.09)	(0.09)	(0.10)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.10)	(0.09)	(0.09)
Financial development	34.69***	18.56***	20.66**	34.02***	26.46***	16.83***	18.24***	18.62***	20.58**	33.57***	26.59***	16.82***	18.07***
	(6.10)	(4.68)	(6.79)	(7.12)	(7.45)	(4.19)	(4.72)	(5.49)	(7.73)	(7.84)	(8.02)	(4.91)	(5.46)
Foreign direct investment	0.05***							0.02	0.08	0.01	0.46***	0.09	0.14***
	(0.00)							(0.21)	(0.22)	(0.25)	(0.00)	(0.26)	(0.00)
Control of corruption		9.64***						9.21***					
		(2.46)						(2.45)					
Governance effectiveness			9.11**						8.26*				
			(3.64)						(3.71)				
Political stability				0.48						0.22			
				(1.98)						(2.21)			
Regulatory quality					5.46						7.77*		
					(3.39)						(3.45)		
Rule of law						10.10***						9.29***	
						(2.14)						(2.25)	
Voice and accountability							9.08***						9.92***
							(2.09)						(2.76)
Control of corruption × foreign direct investment								0.09					
								(0.17)					
Governance effectiveness × foreign direct investment									0.22				
									(0.25)				
Political stability × foreign direct investment										0.22			
										(0.20)			
Regulatory quality × foreign direct investment											0.01***		
											(0.00)		
Rule of law × foreign direct investment												0.20	
												(0.21)	
Voice and accountability × foreign direct investment													0.02***
													(0.01)
Constant	82.49***	72.08***	73.21***	81.80***	77.97***	72.11***	74.49***	72.40***	73.83***	82.16***	76.30***	72.79***	74.01***
	(12.56)	(11.06)	(11.68)	(12.70)	(12.11)	(11.12)	(11.50)	(11.08)	(11.68)	(12.69)	(12.04)	(11.25)	(11.62)
Observations	549	549	549	549	549	549	549	549	549	549	549	549	549
R^2	0.25	0.27	0.27	0.25	0.26	0.27	0.28	0.27	0.27	0.25	0.26	0.27	0.28

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

4.3 Robustness check

In order to validate our findings, we conduct some robustness checks.

4.3.1 Robustness check 1

As the variables used in this study are co-integrated, this study uses the full modified ordinary least square (FMOLS) to account for co-integration. The results are similar to the results reported in the PCSE results. We find that financial development, information technology, trade openness and economic growth have an increasing impact on renewable energy development. Considering our variables of interest, we find that improving governance quality in Africa could spur renewable energy development. Moreover, the impact of foreign direct investment on renewable energy consumption is positive and statistically significant. Similarly, the coefficients of the interaction between foreign direct investment and governance quality are positive and significant.

4.3.2 Robustness check 2

To ensure that our findings are robust, we use alternative renewable energy variable namely renewable electricity output. The results are similar to the previous results when we use renewable consumption as proxy of renewable energy development. However, the results are not reported but are available on request.

Table 5. The FMOLS results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Trade openness	0.10**	0.08**	0.11***	0.09**	0.11**	0.11**	0.09**	0.08*	0.12**	0.10**	0.12**	0.11***	0.09**
	(0.05)	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.06)	(0.05)	(0.05)
GDP per capita	0.00240***	0.00189***	0.00158***	0.00237***	0.00214***	0.00171***	0.00203***	0.00184***	0.00147***	0.00223***	0.00217***	0.00163***	0.00206***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Information technology	0.28**	0.26**	0.25**	0.28**	0.25*	0.24**	0.26**	0.26**	0.25**	0.29**	0.24*	0.25**	0.25**
	(0.09)	(0.09)	(0.09)	(0.09)	(0.10)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.10)	(0.09)	(0.10)
Financial development	34.69***	18.56***	20.66**	34.02***	26.46***	16.83***	18.24***	18.62***	20.58**	33.57***	26.59***	16.82***	18.07***
	(6.10)	(4.68)	(6.79)	(7.12)	(7.45)	(4.19)	(4.72)	(5.49)	(7.73)	(7.84)	(8.02)	(4.91)	(5.46)
Foreign direct investment	0.05***							0.02***	0.08***	0.01***	0.46***	0.09***	0.14***
	(0.00)							(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Control of corruption		9.64***						9.21***					
		(2.46)						(2.45)					
Governance effectiveness			9.11**						8.26**				
			(3.64)						(3.71)				
Political stability				0.48						0.22			
				(1.98)						(2.21)			
Regulatory quality					5.46						7.77**		
					(3.39)						(3.45)		
Rule of law						10.10***						9.29***	
						(2.14)						(2.25)	
Voice and accountability							9.08***						9.92***
							(2.09)						(2.76)
Control of corruption × foreign direct investment								0.09					
								(0.17)					
Governance effectiveness × foreign direct investment									0.22				
									(0.25)				
Political stability × foreign direct investment										0.22***			
										(0.00)			
Regulatory quality × foreign direct investment											0.60		
											(0.36)		
Rule of law × foreign direct investment												0.20	
												(0.21)	
Voice and accountability × foreign direct investment													0.21***
													(0.00)
Constant	82.49***	72.08***	73.21***	81.80***	77.97***	72.11***	74.49***	72.40***	73.83***	82.16***	76.30***	72.79***	74.01***
	(12.56)	(11.06)	(11.68)	(12.70)	(12.11)	(11.12)	(11.50)	(11.08)	(11.68)	(12.69)	(12.04)	(11.25)	(11.62)
Observations	549	549	549	549	549	549	549	549	549	549	549	549	549
R^2	0.25	0.27	0.27	0.25	0.26	0.27	0.28	0.27	0.27	0.25	0.26	0.27	0.28

Standard errors in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$

It is relevant to further discuss the findings in the light of theoretical literature as well as the specific circumstances of sub-Saharan Africa in terms of economic, political and institutional governance dynamics. On the front of theoretical underpinnings, the positive effect of foreign direct investment on renewable energy is consistent with the theoretical strand of the pollution halo hypothesis because environmental sustainability is promoted in terms of renewable energy consumption with the help of foreign direct investment. In the same vein, the positive role of foreign direct investment is contrary to the pollution haven hypothesis, especially as it pertains to the negative role of foreign direct investment in promoting environmental sustainability (McGuire,1982; Zarsky, 1999; Ofori et al., 2023).

The governance context of sub-Saharan Africa supporting the findings can be understood within the remit of recent improvements in political, economic and instutitonal governance across the sub-region. In the light of the IMF (2022), these are discussed from two main perspectives, especially as it pertains to the key elements of governance in the sub-region and governance benefits of countries in the sub-region. First, on the front of evolving key elements of governance, according to the IMF(2022), countries in the sub-region have recently made remarkable improvements in addressing governance deficiencies, to the extend of even outperforming some advanced and emerging economies. According to the narrative, five key points are fundamental for the progress of governance in the sub-region, notably: (i) a substantial degree of political commitment in terms of transparency and good governance; (ii) respect for property rights and the rule of law; (iii) public oversight, transparency and efficiency in the management of investments; (iv) increased access to information and (v) technology and innovation which are essential in helping government realise some priorities.

Looking at the angle of benefits from improved governance, among the documented rewards are aspects of sustainability such as environmental protection (IMF, 2022). For instance, according to the narrative, good governance in the region is *inter alia*, ensuring that: (i) there is equitable distribution of the tax burden and (ii) more government expenditure is oriented towads the achievement of sustainable development goals, especially in the light of increasing access to education and health, mitigating poverty and protecting the environment and (iii) better and more inclusive growth by means of enhanced accountability and transparency.

5. Conclusion and policy implications

This study investigates the moderating effect of governance quality on the influence of foreign direct investment on renewable energy for 37 sub-saharanAfrica countries from 1996-2020. To achieve this goal, this study uses the panel corrected standard errors (PCSE) estimator to account for cross-sectional dependence. The results show that foreign direct investment has a positive and significant impact on renewable energy quality. This means that an increase in foreign direct investment could induce renewable energy. Similarly, the results reveal that there is a positive relationship between governance quality and renewable energy. This means that the improvement of governance quality could lead to an increase in renewable energy. More importantly, the results reveal that the interaction term enters with a positive and significant impact on renewable energy. This means that good governance matters for foreign direct investment to promote renewable energy.

Given the above results, this study provides some policy implications. First, the results reveal that the positive effect foreign direct investment on renewable energy development is statistically significant. This implies that African governments should improve infrastructure and security which plays animportant role in attracting foreign direct investment in the renewable energy sectors. Second, the results show that governance quality seems to have a positive and significant impact on renewable energy. This implies that a critical institutional reform must be done in order to promote renewable energy development. Third, the results unveil that the interaction between foreign direct investment and governance quality appears to have a positive and significant influence on renewable energy. The study recommends that investment policies should be integrated with renewable energy policies in order to attract green foreign direct investment and achieve sustainable development in Africa. Besides, it is also important to improve governance such as reducing bureaucracy, fiscal and incentives measures for foreign direct investmentwhich promote renewable energy consumption.

This study succeeded to examine the moderation of governance quality on the foreign direct invetsment-renenwable energy development nexus in a panel of developing countries. Our study could be improved in several ways. First, due to the difference in then quality of governance between developing countries and developed economies,

the future research may improve this study by investigating the issue in the context of developed countries.This future research direction builds on the caveat that the findings in this study cannot be extended to developed countires, unless empirical validity in developed countries is substantiated. Second, this study can also be improved by future study by investigsting the issue in individual-specific country using time series data. The attendant future research insights build on the shortcoming that, the obsevered heterogeneity can further influence the findings and thus, for more country-specific policy implications, country-specific studies are worthwhile using the relevant time series empirical strategies. Third, future research could use the dynamic esticmation technique to capture the change in the magnitude over the time. Accordingly, renewable energy can be persistent over time and thus an empirical strategy that accounts for the underlying persistence is also worthwhile.

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Table A1. Pesaran (2004)cross-sectional dependence test

Variables	Statistics	p-value
Renewable energy consumption	99.68***	0.000
Renewable electricity output	52.71***	0.000
Control of corruption	24.77***	0.000
Governance Effectiveness	33.51***	0.000
Political stability	4.41***	0.000
Regulatory quality	34.69***	0.000
Rule of law	26.52***	0.000
Voice accountability	12.12***	0.000
FDI	20.01***	0.000
GDP	91.92***	0.000
Trade Openness	70.49***	0.000
Financial development	67.67***	0.000
Information technology	83.46***	0.000

***Indicates 1% level of significance.

Table A2. Pesaran's cross-sectional augmented Dickey–Fuller.

	Intercept	Intercept and trend
Variables	t bar	t bar
Level		
Renewable energy consumption	-3.07***	4.12
Renewable electricity output	-6.51***	0.45
Control of corruption	-10.14***	-1.06
Governance Effectiveness	-12.59***	-4.29***
Political stability	-12.79***	-4.27***
Regulatory quality	-11.35***	-3.80***
Rule of law	-11.08***	-4.02***
Voice accountability	-11.17***	-1.49**
FDI	-16.55***	-6.80***

GDP	-4.52***	5.06
Trade Openness	-9.65***	-0.60
Financial development	-8.20***	-2.51***
Information technology	0.31	0.06
First difference		
Renewable energy consumption	-25.39***	-22.63***
Renewable electricity output	-24.44***	-22.09***
Control of corruption	-21.01***	-16.73***
Governance Effectiveness	-23.21***	-22.37***
Political stability	-23.84***	-23.62***
Regulatory quality	-23.09***	-21.26***
Rule of law	-22.35***	-19.51***
Voice accountability	-20.40***	-15.90***
FDI	-29.11***	-29.95***
GDP	-21.93***	-16.16***
Trade Openness	-23.89***	-20.06***
Financial development	-26.27***	-25.72***
Information technology	-12.84***	-11.75***

***Indicates 1% level of significance

Table A3. co-integration test

	Statistic	p-value
Augmented Dickey-Fuller	-4.23***	0.00

Notes: *** denotes statistical rejection significance at 1% level.