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Do institutional quality and its threshold matter in the sensitivity of the renewable energy transition to financial development? New empirical perspectives

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Abstract

The transition to renewable energy is critical for environmental sustainability, consistent with sustainable development goals (SDGs) 7, 8, 11, 12, and 13 of the United Nations Development Programme (UNDP). Scholars have identified financial development and institutional quality as significant factors determining the renewable energy transition in developing countries. This study opines that the efficiency of the financial system in supporting and providing the substantial financial implications that a switch to renewable energy necessitates depends on the quality of the institutional framework. Weak institutions in developing countries produce loopholes and inherent flaws in the financial system that facilitate corruption and opportunism, ultimately promoting dirty energy usage and technology at the expense of renewable energy. This process suggests that the interaction between financial development and institutions can either accelerate or impede the transition to renewable energy, depending on an economy's institutional architecture. Considering Africa's enormous renewable energy resources, previous research has overlooked the implications of the interplay between institutional quality and financial development in spurring Africa's transition to renewable energy. Thus, this study looks at the role of institutions in moderating the relationship between financial development and renewable energy in Africa from 1990 to 2019, using first- and second-generation estimators to capture econometrics' pitfalls such as endogeneity, cross-sectional dependence, and heterogeneity inherent in the panel dataset. This study departs from previous research in that it uses a dynamic panel threshold to determine the threshold of institutions beyond which financial development is stimulated to spur Africa's transition to renewable energy. The findings show that institutions create loopholes that allow rent-seeking, opportunism, and sharp practices in the African financial system. These inherent flaws divert financial resources to support dirty energy and undermine the financial sector's ability to support a renewable energy transition on the continent. Also, the findings from the threshold of institutions affirm that African countries operate predominantly below the threshold of institutions, over which institutions enable financial development to expedite the continent's transition to renewable energy. The study suggests that institutional quality is essential in the relationship between financial development and Africa's shift to renewable energy. The findings' policy implications are discussed and outlined.

KEYWORDS

Africa, financial development, institutional quality, renewable energy

1 | INTRODUCTION

Energy demand rises in tandem with global economic activity, which is costly to humans and the environment. As a result, human-caused greenhouse gas emissions have increased dramatically (Alam et al., 2021; Omri, Kahouli, et al., 2022; Onifade et al., 2023; Uzar, 2020b). Indeed, these changes are burdening ecosystems and humankind (Adjei et al., 2022; Akam et al., 2022; Aluko et al., 2023; Mukhtarov et al., 2022; Saadaoui & Chtourou, 2022; Zoaka et al., 2022). This disrupts the normal climatic equilibrium brought about by the warming of the earth's surface, resulting in climate re-adjustment and endangering human lives and the ecosystem (Tao et al., 2023). Increased hydrocarbon consumption leads to increased GHG emissions, mainly from fossil fuels, which are the key drivers of global warming (Caby et al., 2022; IPCC, Intergovernmental Panel on Climate Change, 2021; Saba & Biyase, 2022). As a result, it has become a topic of widespread concern, with the Intergovernmental Panel on Climate Change (IPCC, 2021) frequently monitoring the effects of these climate changes. Energy plays a crucial role in the production process. Meanwhile, most of the world's energy needs are met by fossil fuels, which are the leading cause of GHG emissions (Onyeji-Nwogu, 2017). According to the newest data from the Renewable Energy Policy Network for the Twenty-First Century, global energy demand is heavily skewed in favour of fossil fuels as the primary generator of GHGs (REN 21:2021). Thus, international institutions, governments, government agencies, and others have been concerned about environmental preservation by reducing GHG emissions and mitigating climate change's negative repercussions (Xu & Ullah, 2023).

Therefore, a transition to a low-carbon method of production remains the most beneficial to save humanity and preserve the sanctity of the ecosystem (Awijen et al., 2022; Ibrahiem & Hanafy, 2021; Kassouri et al., 2022; Kirikkaleli et al., 2022; Majeed & Hussain, 2022; Omri, Chtourou, & Bazin, 2022; Shahbaz et al., 2022; Shahbaz, Papavassiliou, et al., 2023; Solarin et al., 2022). As a result, switching to renewable energy (REN, henceforth) to decarbonize the economy is an especially appealing alternative (Chu et al., 2023; Eren et al., 2019; Ji & Zhang, 2019; Kassi et al., 2023; Konyeaso et al., 2023; Lin & Wang, 2022; Murshed et al., 2021; Oluoch, Lal, & Susaeta, 2021; Shahzad et al., 2021; Oluoch, Lal, Bevacqua & Wolde, 2021; Wu et al., 2023; Yu et al., 2023). Reducing carbon emissions (CO_2) into the environment can help minimize environmental threats (Kilinc-Ata & Dolmatov, 2023; Xu & Ullah, 2023). It also boosts the economy by eliminating energy poverty and increasing access to energy commodities (Saadaoui, 2022; Sadorsky, 2021). Efforts are being made nationally and internationally to ensure the transition to low-carbon energy usage. The 2015 Paris Agreement marked a turning point in the global push for low-carbon energy consumption (Caglar et al., 2022). In addition, article 2 of the worldwide legal climate accord stresses the importance of decreasing global warming to "well below 2°C," a 4°C drop from current levels (see COP 21 of the United Nations Framework Convention on Climate Change). It is equally consistent with the Sustainable Development Goals (SDG) number 7, 11, 12, and 13 of the United Nations Development Programme (UNDP), which stresses REN (clean energies) as enablers of sustainable development. Actualization of this lofty global goal requires extensive international team-up. Though the desire to transition to low-carbon energy is technically feasible and beneficial to humanity and the ecosystem, the processes tend to be gradual rather than instantaneous (the International Renewable Energy Agency, IRENA, 2018). It implies that moving from the dominance of high-carbon energy systems to a more sustainable path needs long-time plans and the persistent efforts of policymakers and stakeholders across the globe (Saadaoui, 2022; Saadaoui & Chtourou, 2023).

Transiting from polluting to clean energies cannot be radical. It follows gradual processes. Meanwhile, persistent and sustained efforts must be made toward its actualization. Advanced countries appear to be leading the struggles of the energy transition to a more sustainable development path, and the drives are gradually spreading to emerging and developing countries (Belaïd et al., 2021; Onifade & Alola, 2022; Saadaoui, 2022). Besides, transitioning from fossil fuel-based mechanisms to clean energy solutions as the main policy instrument to spur a low-carbon economy is capital-intensive and costly (Karekezi & Kithyoma, 2003; Kim & Park, 2016; Lahiani et al., 2021; Nwani, 2022). Renewable energy is more expensive to produce than fossil-fuel-based energy (Bamati & Raoofi, 2020; Mukhtarov et al., 2020; Prempeh, 2023; Yu et al., 2023). The transition to renewable energy requires initial substantial capital investments, long-term debt repayment plans, constant investment in research and development, and high-powered infrastructures (Majeed & Hussain, 2022; Prempeh, 2023; Saygın & İskenderoğlu, 2022; Shahbaz et al., 2022; Somoye et al., 2023; Wang & Dong, 2021; Wu & Broadstock, 2015). These heavy financial burdens restrict the transition and deployment of REN to decarbonize the world's ecosystems (Aziz, 2023; Appiah-Otoo et al., 2023; He et al., 2019). Thus, well-functioning and developed financial systems are essential to ease the process of transition through financing environmentally friendly technologies at lower costs that ensure low-carbon emissions and reduce energy poverty (Alsagr & van Hemmen, 2021; Amuakwa-Mensah & Näsström, 2022; Barua & Aziz, 2022; Chang et al., 2022; Dimnwobi et al., 2022; Khezri et al., 2021; Mukhtarov et al., 2020; Nwani et al., 2021; Samour et al., 2022; Yu et al., 2023). Contrarily, weak or underdeveloped financial systems stunt the transition and impair the substitution of fossil fuels for clean energies (renewable energies). This suggests that financial development (FD, henceforth) is critical to the production of REN (Khan, Khan, & Binh, 2020; Pham, 2019; Saygın & İskenderoğlu, 2022; Shahbaz, Papavassiliou, et al., 2023; Shahbaz, Topcu, et al., 2021). Efficient allocation of financial resources to stimulate the REN transition cannot be feasible without an efficient and virile financial system (Pata et al., 2022; Raza et al., 2020; Somoye et al., 2022). Thus, the significance of FD as a critical ingredient to finance the heavy financial obligations required to spur the REN transition remains vital to decarbonizing the economy (Alsagr & van Hemmen, 2021; Dimnwobi et al., 2022; Pata et al., 2022). Meanwhile, the quality of institutional frameworks in an economy has been suggested as one major factor in the essential role that FD plays in accelerating the transition to REN. The pathways and transmission channels through which institutional quality influences the role of financial development in accelerating renewable energy transitions are fundamental. The institutional channel is critical to the financial sector's ability to spur the energy transition. They should be adequately addressed in the theoretical and empirical literature.

The level of quality of institutions in an economy determines how effectively and efficiently the financial system functions to channel financial resources to put an economy on a sustainable path of catalyzing the transition to REN (Belaïd et al., 2021; Majeed & Hussain, 2022; Pata et al., 2022). Strong institutional architectures are enablers to prevent the financial systems' inherent flaws, which check opportunistic behaviour, deceptive manoeuvres, and rent-seeking activities. As a result, financial resources are effectively utilized to finance the shift to clean energies and renewable energy sources. Strong institutions are crucial for increasing financial sector efficiency and prioritizing resource allocation to clean energy production and consumption to decarbonize the economy. Effective institutions provide momentum and impulses for the financial sector to prune finance for dirty energy consumption and use it to favour renewable energy. An improved institution allows stakeholders and government agencies to provide the institutional support required to motivate the financial sector to commit more resources and loan schemes to finance high-powered infrastructures needed by renewable energy investors and consumers. Thus, efficient institutions supplement financial development to accelerate the transition to renewable energy.

On the contrary, weak or inadequate institutional frameworks may result in vulnerabilities that abet corrupt activities that weaken the financial sector's capacity for financial intermediation and divert resources away from financing environmentally friendly technologies that might lead to the transition to renewable energy production. This indicates that the institution serves as a moderator between FD and the switch to REN. It also implies that it is not just FD, in general, that is important for the transition to clean energy but FD that is rooted in a strong institutional framework. More finance may not likely stimulate massive and viable investment in low-carbon energies without efficient institutional frameworks to prevent loopholes and guide the processes of financial intermediations to spike an increased investment in renewable energy consumption. The implication is that for FD to be genuinely green to spur low-carbon energy by investing massively in renewable energy options (He et al., 2019), efficient and effective institutional architectures must be put in place to ensure the investments are not wasted (Ye et al., 2022) or being utilized to finance non-environmentally friendly technologies and energies (Dada, Adeiza, et al., 2022; Dada, Olaniyi, et al., 2022; Majeed & Hussain, 2022). Therefore, it is shown that without adequate and robust institutional frameworks, the limited resources for investment in renewable energy production from the financial system may be diverted (Wu & Broadstock, 2015). Some previous research has investigated the roles of institutions as ingredients that stimulate FD by preventing loopholes in the financial system which spurs financial intermediaries to be efficient in the allocation of resources (Ahamed et al., 2021; Ahmad & Law, 2024; Girma & Shortland, 2008; Huang, 2010; Khan et al., 2019; Khan, Khan, & Zuojun, 2022; Olaniyi, 2022; Olaniyi & Adedokun, 2022; Olaniyi & Oladeji, 2021, 2022; Raza et al., 2020; Voghouei et al., 2011). Following this assertion, empirical studies have started investigating the crucial roles of FD and institutional quality (INST, henceforth) in facilitating the transition to renewable energy sources as a reliable route for decarbonizing the economy.

A plethora of existing research has examined the separate effects of both FD and INST on REN with mixed and conflicting research outcomes (Abeka et al., 2022; Anton & Nucu, 2020; Belaïd et al., 2021; Bourcet, 2020; He et al., 2019; Pata et al., 2022; Saadaoui, 2022; Saadaoui & Chtourou, 2022; Tinta, 2022; Wu & Broadstock, 2015). Meanwhile, studies on the effects of the interactions between finance and institutions on renewable energy transition are scanty. This happens despite the significance of INST in moderating how FD influences the switch to clean energy sources such as REN; only Belaïd et al. (2021) and Ndubuisi et al. (2023) examine how institutions and FD interact to accelerate the switch to renewable energy sources. Also, the study's findings and policy suggestions from Belaïd et al. (2021) are strictly constrained because it focuses exclusively on nine MENA countries. Such policy dimensions might not be adequate to address the peculiar situations and characteristics of other regions like Africa. Similarly, despite heavy and extensive international transactions and integrations among African countries, Ndubuisi et al. (2023) exclusively studied the case of sub-Saharan African countries, neglecting crucial econometric pitfalls such as cross-sectional dependence and heterogeneity. These omissions may distort empirical findings and result in incorrect policy dimensions, which could thwart the switch to renewable energy in Africa.

This study surpasses the earlier work of Ndubuisi et al. (2023) by employing more advanced and robust second-generation estimators. We use a class of estimators that are resistant to dealing with the panel dataset's inherent cross-sectional dependence and heterogeneity, such as the Driscoll-Kraay nonparametric covariance matrix estimator, the pooled mean group (PMG), the augmented mean group (AMG), and the common correlated effects mean group (CCEMG). We equally use another set of estimators, such as the system generalized method of moments, fully modified ordinary least squares, and dynamic ordinary least squares, to account for endogeneity issues inherent among the variables. As a result, this study offers the first robust attempt in Africa to investigate the particular features surrounding how institutional development moderates the effect of FD on the continent's transition to REN. Some studies have examined the drivers of REN in Africa and SSA in particular (Akintande et al., 2020; Akpalu & Wilson, 2021; Amoah, Kwablah, et al., 2020; Apergis et al., 2018; Asongu & Odhiambo, 2019; Asongu & Odhiambo, 2021a; Attiaoui et al., 2017; Baye et al., 2021; da Silva et al., 2018; Ibrahiem & Hanafy, 2021; Nyiwul, 2017; Olanrewaju et al., 2019; Oluoch, Lal, & Susaeta, 2021; Rashed et al., 2022; Somoye et al., 2022), but they have not specifically investigated the influence of institutional architectures in spurring FD to enable or mar the renewable energy transition. Also, issues surrounding and besieging Africa's institutional and financial developments tend to have serious implications for the switch to REN. Thus, empirical investigations in this regard are highly imperative and of policy relevance to the entire region and countries.

Aside from this interactive effect, this study distinctively makes a compelling case that institutional development has to attain and surpass a certain threshold level before it can become a powerful driver of FD, causing and driving significant investment in clean technologies that will enable the switch to renewable energy alternatives. It is argued that institutional architectures below the threshold may be too weak or uncertain about circumventing rent-seeking activities, fraudulent dealings, opportunistic behaviour, sly and corrupt practices, and flaws in the financial system that might abet the diversion of financial resources to finance dirty or environmentally unfriendly energy options (non-renewable energy and fossil fuel-based energy sources), which are likely to endanger and threaten the ecosystem and humanity rather than improving it. However, strong institutions above the threshold are essential to block loopholes and forestall shady dealings in the financial system, enabling financial resources to be adequately channelled to finance clean and renewable energy variants. This connotes that INST has to persistently be above the threshold before it provides the necessary impetus to complement FD to finance adequate investment in renewable energy options to decarbonize the ecosystem. Consistent with this proposition, this study differs from existing research by unearthing the INST threshold, beyond which institutions become potent catalysts that spur FD to release financial resources needed to enable rapid development in the production of REN. The case of Africa is considered in this study because the institutional development is averagely weak (Aluko & Ibrahim, 2020a; Olaniyi, 2022; Olaniyi & Oladeji, 2021), and the financial system is shrouded in corrupt practices and financial improprieties, while renewable energy potentials of the region are underexploited (Amigun et al., 2008; Karekezi & Kithyoma, 2003; Schwerhoff & Sy, 2017). This study is extremely beneficial to African countries because it will enable the stakeholders and policymakers to set realistic targets for institutional and financial developments that will spur the switch to renewable energy options.

Compared to previous research, this study bridges gaps by providing more insights and debates into the critical roles of institutions in influencing and moderating how financial development propels the renewable energy transition in Africa. One, this study is a maiden effort to consider the particular cases of how institutional apparatuses and financial development interplay to spur renewable energy transition in Africa. Two, this study deviates from earlier studies in the global discussion by using more robust estimators such as Driscoll–Kraay nonparametric covariance matrix estimator, PMG, AMG, and CCEMG to take care of cross-sectional dependence and heterogeneity revealed among the understudied variables, which have been neglected in the previous studies on the chemistry of financial development and institutional quality to accelerate the switch to renewable energy. Three, this study is the first to determine the threshold of institutional quality above which institutions provide a stimulus to financial development to spur the switch to renewable energy within the context of a dynamic panel threshold. The approach delivers a more robust threshold level that accommodates endogeneity and dynamism of how variables behave before and after the threshold point.

Overall, our findings attest to robust evidence of cross-sectional dependence and heterogeneity among the financial development—institution—renewable energy trilogy. The study's key findings reveal that financial development and institutional quality are separate positive drivers contributing substantially to accelerating Africa's renewable energy transition. Meanwhile, rather than complementing financial development to expedite Africa's transition to renewable energy, institutional quality acts as a drag, creating loopholes and flaws in the financial system. These findings indicate that Africa's institutional architecture abets corrupt practices and opportunistic behaviour in the financial system. This culminates in diverting the financial system's resources and support away from renewable energy technology and deployment in Africa. The findings imply that as financial development expedites Africa's transition to renewable energy, institutions thwart the process and weaken the ability of the financial sector to accelerate the switch. Hence, the institutional framework guiding the financial sector operations in African countries should be scrutinised to correct inherent loopholes that channel resources to dirty energy technology and consumption at the expense of clean energy deployment and production.

These findings are robust to various estimators and robustness checks. Our findings on the threshold of institutional quality in the finance-renewable energy nexus show that African countries operate predominantly below the threshold point. These results corroborate the earlier research outcomes, which affirm that Africa's institutional architecture punctures and weakens the positive drives of financial development needed to spur the switch to renewable energy. It implies that Africa's institutional development is weak. It accommodates loopholes in the financial system that allow financial resources to be diverted to fossil fuel-based energy consumption at the expense of renewable energy. As a result, Africa's institutions need to be more solid to properly enhance the financial sector in expediting the continent's transition to clean energy. The implications of research findings and deduced policy recommendations are carefully drawn and discussed.

Except for this introduction, the other Sections are organized as follows: rationale for the study in Africa is explained in Sections 2 and 3 gives a comprehensive analysis of the body of existing literature, and Section 4 focuses on the data description, methodological approaches, and estimating techniques. Section 5 presents and discusses the findings' implications. While Section 6 focuses on practical contributions and policy recommendations, the overview and conclusion are delivered in Section 7. The article's final Section lists the study's limitations.

2 | THE RATIONALE FOR THE STUDY IN AFRICA

Despite the substantial benefits of renewable energy (REN) for decarbonizing the environment, Africa seems to be underutilizing its wealth of renewable energy resources because of the enormous financial resources needed for investment, production, deployment, and the inadequacy of institutional support. This may have an impact on policies relating to REN. These contemporary issues and challenges could obstruct Africa's transition to REN if not adequately managed. These problems seriously threaten the transition to REN and technologies. The following briefly explains some of the main issues with the trilogy of FD, institutions, and REN in Africa:

One, examining the factors, most especially FD and INST that explain the renewable energy transition in Africa is very crucial because it will help the region map out appropriate strategies to reduce fossil fuel-based energy consumption and ward off the adverse effects of climate change to attain environmental sustainability following Sustainable Development Goals (SDGs) number 7, 8, 11, 12 and 13 to decarbonize the ecosystem and humanity in the region. Also, British Petroleum (2020a, 2020b) estimates that Africa's total renewable electricity consumption was 32,558 million tons in 2018, which reflects a slow switch to REN. Two, according to studies, Africa emits CO_2 at a rate significantly higher than that of the rest of the globe (Adjei et al., 2022; Espoir & Sunge, 2021). This implies that environmental pollution in SSA increases faster than the global rate. The annual growth of environmental pollution (CO_2) in SSA is 1.74%, while the global yearly rate is 1.47% from 1991 to 2019 (Espoir & Sunge, 2021). For instance, the percentage was 2.10 between 1960 and 1980, but it increased progressively to 3.18% between 1981 and 2000, and it further climbed to 3.64% between 2001 and 2019 (Adjei et al., 2022; World Resources Institute, 2021). This signals that non-renewable energy consumption might have increased at the expense of renewable energy options in Africa, which could threaten the ecosystem and humanity. Thus, exploring factors, such as INST and FD, that could spur the switch to clean energy sources (renewable energies) in Africa becomes highly imperative. Three, according to the statistics provided by BP Energy Outlook (2020), fossil energy still accounts for 90.5% of total energy production in Africa's energy generation mix, while renewable energy sources account for only 9.5%. It reveals that Africans predominantly rely on dirty and polluting energy generation at the expense of clean and environmentally friendly energy. It highlights the importance of examining factors that could facilitate the renewable energy transition in Africa.

Four, it has been reported that Africa's potentials for renewable energy resources are grossly underexploited (Amigun et al., 2008; da Silva et al., 2018; Olanrewaju et al., 2019). It implies that Africa is rich in renewable energy resources (Attiaoui et al., 2017; Bugaje, 2006; Ergun et al., 2019), which can solve climate change problems in the region if adequately harnessed. It is also confirmed that only 7% of hydropower potentials in Africa are harnessed (Karekezi & Kithyoma, 2003; Olanrewaju et al., 2019; Schwerhoff & Sy, 2017). This suggests that the remaining 93% of potentials are lying idle. Hence, most African nations are working to create strategies and regulations that will enable them to sustainably utilize their abundant renewable energy resources (Ergun et al., 2019). Five, energy poverty is prevalent in Africa. The region has more people living without electricity than any other region. SSA energy security is the lowest globally (Nyiwul, 2017). Despite producing only 4% of the world's total energy needs, the region is home to 13% of the world's population (IEA, 2015). Recent research finds that more than 612 million people live without access to electricity, almost half of the world's population (da Silva et al., 2018). Due to rapid population growth exceeding the several effective initiatives to offer access, it is also the only region in the world where the number of people without electricity is rising. **Six**, Africa's energy crisis is not due to a lack of energy resources but the inability to provide adequate infrastructural, institutional, and financial support and appropriate technologies to harness and exploit the abundance of renewable energy resources (Bugaje, 2006; Ergun et al., 2019). These point to the essential roles of FD and institutional architectures could play in the region's transition to renewable energy alternatives by efficiently allocating resources to its production.

Seven, despite its importance and benefits, the share of REN in total energy production and consumption in Africa is comparatively low compared to the world average. According to data from the world development indicators (The World Bank, 2018) for the years 1996 to 2018 (2016–2018 projected), the global average growth rate of the production of modern renewable energy worldwide is 8.43% higher than that of Africa. This accounts for over half of the quantity produced in Africa (Amoah, Appiah, et al., 2020). Eight, despite the SSA region enjoying the lowest contribution to global CO_2 emission, it has been found that SSA is the most vulnerable to climate change in the world (Adzawla et al., 2019; Edmonds et al., 2020; Sarkodie, 2018). The recent statistics support that SSA contributes the least to global CO_2 emission (4%) while other regions such as Asia, North America, Europe, Latin America, and the Caribbean which contribute 49%, 17%, 16%, and 6%, respectively (Aluko & Obalade, 2020; Ritchie & Roser, 2019). Thus, the SSA's vulnerability to climate change has necessitated the focus of policymakers, stakeholders, and academics to be switched to REN in line with the sustainable development goals (SDG) number 7, 8, 11, 12, and 13 of the United Nations Development Programme (UNDP). It also implies that there should be massive investment in clean technologies and renewable energy options across SSA countries.

Nine, renewable energy production requires huge initial capital investments, making redeployment difficult for the poor populace in Africa. It has been determined that the lack of capital resources in most African countries makes investments in renewable energy expensive (Attiaoui et al., 2017; Muoneke et al., 2023). If not sponsored or subsidized, many might prefer fossil fuel-based energy sources that are not too financially burdensome to them. This has constituted a great barrier to the switch to renewable energy options (Mohammed et al., 2013). This has impaired the development of renewable energy options in Africa. Africa's financial system does not favour small-scale investment in REN, which is a prerequisite to deploying clean energy technologies (Amigun et al., 2008). When credit facilities are available for renewable energy investors, the interest rates are so high that investors consider it too risky to venture into it (Mohammed et al., 2013). It has also been confirmed that the SSA region only contributed 0.3% of the total global investment in REN (IRENA, 2016). This signals the crucial role of the financial sector in financing clean energy options in Africa. Meanwhile, FD in Africa is shrouded by certain issues that could inhibit its efficiency in allocating resources to spur the switch to renewable energy options.

Ten, Africa's FD appears to be the least developed in the whole world (Allen et al., 2011; Andrianaivo & Yartey, 2010; Demetriades & Fielding, 2012; IMF, 2016; Kuada, 2016; Olaniyi, 2022; Olaniyi & Oladeji, 2022, 2021; Tyson, 2016). The facts in several studies have established the backwardness of FD in Africa compared to other regions across the globe (Aluko & Ibrahim, 2020a, 2020b; Aluko & Obalade, 2020; Mlachila et al., 2016). It signals that most African countries still operate within the confines of the underdeveloped financial system (An et al., 2021; Muoneke et al., 2023). The underperformance of the financial system in Africa might have undermined and distorted financial intermediaries' ability to mobilize financial resources to finance massive investments that will spur the deployment of REN. Many scholars have attributed the weak performance of FD to weak institutional development in Africa (Olaniyi, 2022; Olaniyi & Oladeji, 2021).

Eleven, weak institutional apparatuses and the environment appear to be major factors that could limit the potential of African countries to explore clean technologies and renewable energy options (Abeka et al., 2022; Amoah et al., 2022; Amoah, Appiah, et al., 2020; Amoah, Kwablah, et al., 2020). A weak institutional framework tends to breed corruption and thwart the strategic plans and necessary regulatory mechanisms to actualise the renewable energy transition (Karim et al., 2022; Uzar, 2020a, 2020b). Massive investment in renewable energy production might not yield the expected results if the institutional architectures are not firmed up to ameliorate the financial and operational efficiencies in the production (Abeka et al., 2022). The quality of the institutions equally has a great likelihood of influencing the political dimensions of switching to REN, which could make or mar the processes (Abeka et al., 2022; Uzar, 2020a, 2020b). This corroborates the earlier findings of Uzar (2020b) that corruption control can prevent loosening environmental policies and encourage massive investment in renewable energy production and clean technologies. In Africa, regulatory and policy, technical, institutional, and financial constraints constitute barriers to developing and using renewable energy technology (Nyiwul, 2017). It has been documented that the main obstacles impeding investment in REN in African nations are lax regulatory frameworks and policies (Asante et al., 2020; Saadaoui & Chtourou, 2022).

Following this position, some studies have established that weak institutions could hamper FD from playing the role of intermediation (Abaidoo & Agyapong, 2022; Aluko & Obalade, 2020) to finance renewable energy options. Thus, weak institutions in SSA tend to drain the positive influence of FD on the transition to REN. Against this backdrop, it appears that both institutional and financial developments are weak. This makes the case of African countries interesting research to explore the effects of the interaction between FD and INST on the switch to REN. Thus, this current study makes a maiden effort to examine the moderating role of INST in how FD influences the transition to REN in Africa. Additionally, by identifying and uncovering the potential presence of an institutional quality threshold in the relationship between FD and REN, this study adds to the general discussion in the body of existing studies for the first time.

3 | OVERVIEW OF AFRICA'S PERFORMANCE IN INSTITUTIONAL QUALITY AND FINANCIAL DEVELOPMENT

This section discusses the averaged performances of African countries in the key variables of the study to complement the rich explanations of the rationale for the study in the case of Africa. The graphical illustrations of the IMF broad-based index of financial development for the 34 African countries covered in this study are presented in Figure 1. The index ranges between 0 and 1. As sketched in Figure 1, the data indicate that all African countries perform below average. From 1990 through 2019, Africa's continent had an average of 0.1276, compared to 0.4596 for Europe, 0.2932 for Asia and the Pacific, and 0.2221 for the Middle East and Central Asia. South Africa is the best-performing country on the continent, with an average of 0.4954, while the least-performing country is Guinea-Bissau, with an average value of 0.0460. This implies that the African financial system still lags in the global rankings. In a comparative analysis, the United States and Australia have average values of 0.8354 and 0.8151 over the same period. These statistics indicate that the African financial system appears weak compared to other continents. The weak financial system in Africa tends to drag on the continent's prospects to finance the huge financial requirements to exploit the underutilized abundant renewable energy resources that will accelerate the transition to clean energy and decarbonize Africa. Aside from the performance of Africa's financial system, extant studies have shown that institutions are essential drivers of the switch to renewable energy options.

Figure 2 shows the average performance of institutional development for African countries. After rescaling all five institutional measures (democratic accountability, corruption control, law and order, government stability, and bureaucratic quality) to 0–10, we compute the

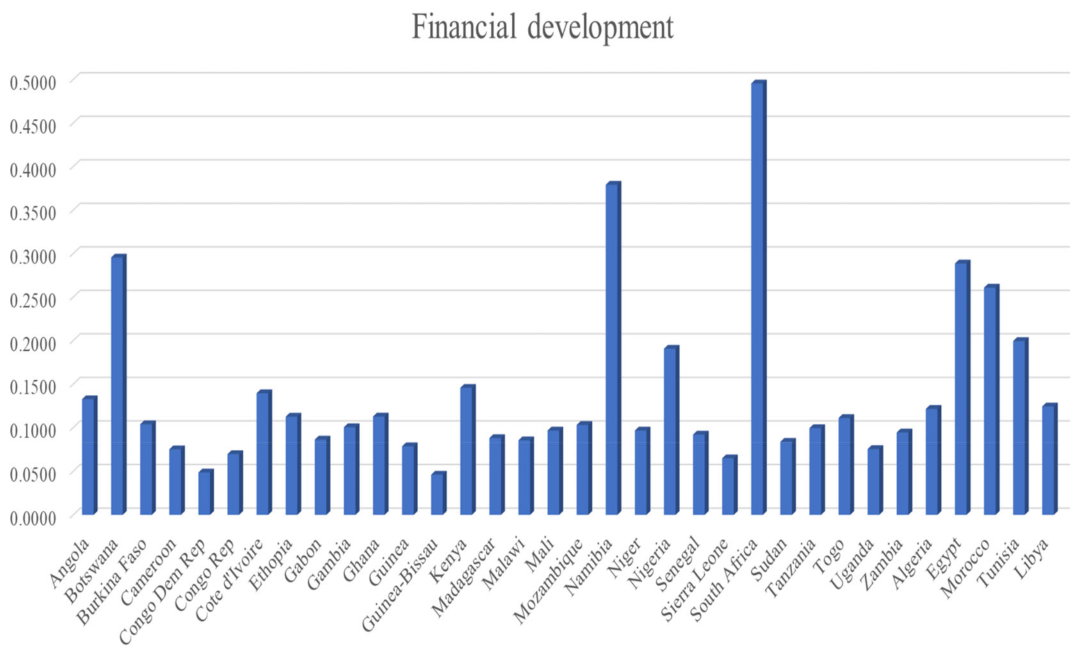

FIGURE 1 Average value of Financial Development Index in Africa. [Colour figure can be viewed at wileyonlinelibrary.com]

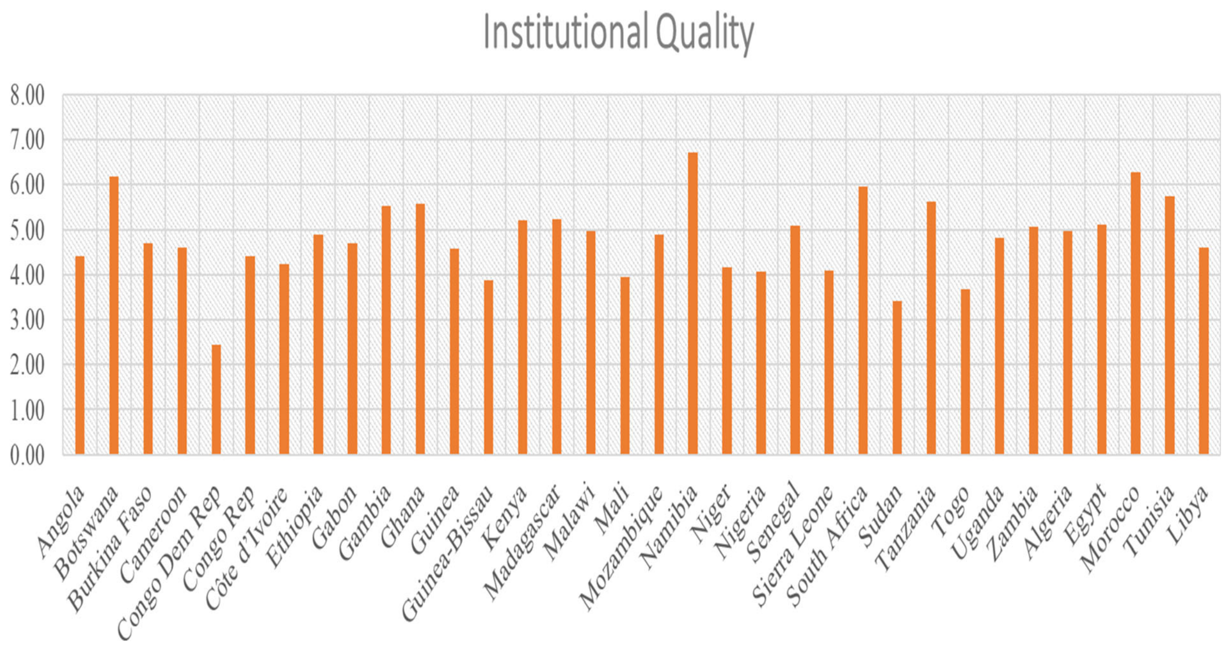

FIGURE 2 Average value of institutional quality in Africa. [Colour figure can be viewed at wileyonlinelibrary.com]

average value to obtain the overall institutional index. The average performance of African countries in institutions for the period 1990–2019 is 4.84 out of a possible 10. This value is below the average. It signals that Africa's institutions are weak, and they have a high likelihood of accommodating loopholes and flaws in the financial system to thwart the process of reducing the cost of borrowing to finance the production and consumption of renewable energy in Africa. In Figures 1 and 2, there are puzzles to unravel. The best-performing country in terms of financial development is not the best-performing in terms of institutional quality. Namibia has the best institutional development in Africa but ranks second in financial development. Also, South Africa has the most advanced and sophisticated financial system in Africa, but it takes the fourth position in institutional development. The general performances of African countries in financial and institutional development do not give clear directions as to whether the two variables complement or impede each other on the path to spurring the renewable energy transition. There is a need to examine how institutions and financial development interact to accelerate or impede Africa's transition to renewable energy options.

4 | REVIEW OF THE LITERATURE

4.1 | Theoretical perspective

The relationship between FD, INST, and renewable energy (REN) consumption is examined in this section from theoretical and empirical angles. Renewable energy costs more than traditional fossil energy options. Thus, the growth of renewable energy requires more access to financial resources. As a result, a well-developed financial sector can facilitate investment in renewable energy sources. Financial development contributes to the transition to renewable energy by reducing information asymmetry, easing bureaucratic procedures surrounding access to credit facilities, lower costs of capital, and more effective capital allocation. According to economic theory, FD can affect investments in and usage of REN (Pata et al., 2022). A well-developed financial system can easily set up the credit facility arrangements and financial support needed to fulfil the demand for the consumption and production of REN. This will help meet consumers' renewable energy demands and ease its production for producers. Also, an advanced stock market can assist renewable energy firms in raising financial capital that will facilitate investment and production of REN. These suggest that both financial institutions and markets are instrumental to the renewable energy transition by raising the needed capital and financial resources for investment and production. Following the economic theory, FD can influence renewable energy consumption, investment, and production through three primary channels: direct effects, business effects, and wealth effects (Anton & Nucu, 2020; Majeed & Hussain, 2022; Sadorsky, 2011). The direct effect is the process through which efficient financial intermediation of a financial system enables consumers to access financial resources. This enables them to patronize durable and high-powered technology, which spurs increased demand for renewable energy. The business effects highlight a phenomenon when renewable energy companies have easier access to financial capital due to an accelerated pace of FD. Renewable energy companies now have relatively affordable access to financial funding as the financial system develops. This procedure enables businesses to boost their investment in and production of renewable energy, raising their demand for renewable energy.

Wealth effects centre on the attractive roles of the stock market development in assisting renewable energy companies to have access to raise additional funds, most especially equity financing, which could be used to widen the scope of their business in support of debt financing. The increase in stock market activities helps to create wealth by diversifying the risks and bolstering confidence in economic activities for both consumers and producers of renewable energy (Sadorsky, 2011; Shahbaz, Topcu, et al., 2021). Aside from the theoretical exposition on channels through which FD influences REN, it is explained that the effects of FD's role in promoting renewable energy may have to pass through institutions. Corrupt institutions are willing to encourage opportunistic behaviour and rent-seeking, which abet the misappropriation of funds that could serve as subsidies and encouragement for companies and business ventures to employ renewable energy technologies in their operations (Kassi et al., 2023). As a result, effective institutions like corruption control and bureaucratic quality are necessary to correctly apply regulations and regulatory policies that promote long-term investment in renewable energy technologies. This indicates that corruption and a weak institutional framework tend to thwart the operations of the financial system to support and finance sustainable investment in renewable energy technologies and consumption. High corruption in the financial sector tends to support massive investments in fossil energy consumption and technologies that increase carbon dioxide emissions by impairing the process of implementing policies and environmental regulatory frameworks that promote the switch to renewable energy consumption.

Due to the critical of institutions, the law-and-finance theory is introduced to bridge the gap and correct the potential inefficiencies in the financial system by strengthening the intermediation role of FD via an institutional approach. The theory posits that sound legal institutions are key factors that facilitate the growth of the financial sector and its ability to play the role of intermediation. It stresses that strong institutions block loopholes in the financial system and prevent rent-seeking activity, corruption, and financial improprieties. Thus, sound institutions build up the confidence of the stakeholders in financial transactions of financial institutions and markets. Efficient institutions sanitize and incentivize the financial system to channel more resources to support and finance activities that will accelerate the switch to renewable energy. Weak institutions and corrupt practices often thwart efficient investments. It breeds bottlenecks, corruption, and a decline in the quality of institutions, which inhibit the efficient allocation of resources to long-term investments, including long-term investments in renewable energy. Thus, the financial sector's long-term support and investment in renewable energy tend to be impaired when the quality of institutions is flawed. This demonstrates that without strong institutions, the financial sector's ability to finance and support renewable energy deployment, production, and investment may be less effective. The study hypothesizes that institutions play key roles in influencing and moderating the impact of finance on the renewable energy transition.

4.2 | Empirical evidence

The global threats that fossil fuel-based energy consumption and production constitute to the ecosystem and humanity have led international organizations and institutions to consider transitioning to REN and clean technology. Several factors have been identified to facilitate the move to clean energy. Financial development, institutional quality, foreign direct investment, energy price, population, income, economic structure, urbanization, and other factors are identified in the extant literature. As a result of the significant financial implications and high capital investment required to transition to REN, more emphasis has been placed on financial development. It has also been argued that the effective roles of FD depend on the prevailing institutional architecture. Strong institutions facilitate the financial system's efficiency by preventing the lapses, opportunistic tendencies, and corrupt practices that could thwart the channelization of resources to renewable energy and clean technology.

On the other hand, weak institutions divert resources away from renewable energy and clean technology, which promotes dirty energy consumption and worsens environmental degradation. It indicates that the financial sector's ability to spur the renewable energy transition depends on the overall institutional framework in an economy. This is in tandem with the assertion that institutional quality, good governance, and financial sector development constitute the most critical barriers to the renewable energy transition in emerging and developing countries (Belaïd et al., 2021; García, 2013; Painuly & Wohlgemuth, 2006). Hence, it is in the right order to examine empirically how finance and institutions interplay to determine the switch to REN in developing countries like African countries. Following this stance, a review of empirical studies is done by pairing the variables.

4.2.1 | Financial development and renewable energy

A plethora of studies have examined the effect of FD on REN. Meanwhile, the outcomes of extant research are mixed and conflicting. In a recent effort, Alsagr and van Hemmen (2021) adopted a two-step generalized method of moments (GMM) to analyze the data of emerging economies for the period 1996–2015. The study establishes that FD is instrumental to the renewable energy transition. This result aligns with Sadorsky's (2010) research, which confirms that FD decreases credit costs, reduces finance-related risks, and permits resource allocation accountability. As a result, FD tends to encourage the use and production of renewable energy. Similar results are also obtained in a study by Belaïd et al. (2021), which establishes FD as a positive enabler of renewable energy production in a sample of nine MENA countries within the ambit of panel quantile regression. The research outcomes of Pata et al. (2022) align with this result, as it reveals that FD encourages the consumption of renewable energy in the case of the USA. Based on the summary of the literature matrix presented in Table 1, it is predominantly evident that thirty-two studies out of the total forty-seven reviewed supported the renewable energy-enhancing roles of FD to facilitate the transition. This points to the significance of FD in the moves to carbon-neutral energy deployment and technology. The process is highly capital-intensive and needs substantial financial resources. Thus, effective transitioning to renewables needs a well-functioning financial system to ease the financial burdens. Meanwhile, this position has been predominantly supported in the existing research, but it has not been unopposed in the existing empirical research. In recent research efforts, a few studies have established either adverse or insignificant effects of FD on REN.

There is a class of empirical studies, including Muoneke et al. (2023), Ankrah and Lin (2020), Jamshid et al. (2022), Kwakwa (2021), Saadaoui and Chtourou (2022), Shahbaz et al. (2018), and Wang et al. (2021), that have adopted various econometric methodologies and approaches to establishing the repressing effects of FD on the transition to REN. This may have implied that FD favours energy and technologies associated with fossil fuels to the detriment of clean and environmentally sustainable renewable energy. Some other studies, including Assi et al. (2021), Burakov and Freidin (2017), Lei et al. (2022), and Mehrara et al. (2015), have established the insignificant roles of FD in the moves to REN. This may suggest that FD plays a passive role in supporting the renewable energy transition. The last group of studies, including Khezri et al. (2021), Saadaoui (2022), and Saygın and İskenderoğlu (2022), report mixed findings on the impact of FD on REN. The critical review, as reported in Table 1, reveals that the literature on the impact of FD on REN remains inconclusive, and it is far from being settled.

TABLE 1 Studies on the roles of financial development in renewable energy transition.

Study	Data span	Country	Technique	Findings
Kutan et al. (2018)	1990–2012	Brazil, China, India, and South Africa	Group-Mean FMOLS	FD ↑ REN
Anton and Nucu (2020)	1990–2015	28 European countries	Panel fixed effect model	FD ↑ REN
Shahbaz et al. (2018)	1992–2014	16 developing countries	CCEMG and AMG	FD ↓ REN
Eren et al. (2019)	1971–2015	India	DOLS	FD ↑ REN
He et al. (2019)	2011–2016	China	Panel fixed effect model	FD ↑ REN
Ji and Zhang (2019)	1992–2013	China	VAR model	FD ↑ REN
Khan et al. (2021)	2000–2014	69 Belt and Road Initiative countries	GMM	FD ↑ REN
Lahiani et al. (2021)	1975Q1-2019Q4	USA	NARDL	FD ↑ REN
Shahbaz, Topcu, et al. (2021)	1994–2015	34 developing countries	FMOLS	FD ↑ REN
Wang et al. (2021)	1997–2017	China	ARDL-PMG	FD ↓ REN
Shahbaz et al. (2022)	2000–2019	39 countries	CS-ARDL	FD ↑ REN
Majeed and Hussain (2022)	1970–2020	173 countries	Dynamic panel threshold	U-shaped
Saba and Biyase (2022)	2000–2018	35 European countries	FOLS, DOLS and GMM	FD ↓ REN
Wu and Broadstock (2015)	1990–2010	22 emerging countries	GMM	FD ↑ REN
Brunnschweiler (2010)	1980–2006	119 non-OECD countries	GMM	FD ↑ REN
Kim and Park (2016)	2000–2013	30 countries	OLS	FD ↑ REN
Alsaleh and Abdul-Rahim (2019)	1990–2013	28 European Union countries	Panel ARDL	FD ↑ REN
Assi et al. (2021)	1998–2018	ASEAN +3 economies	Panel ARDL	FD ≠ REN
Lei et al. (2022)	1990–2019	China	NARDL	FD ≠ REN
Mehrara et al. (2015)	1992–2011	9 Economic Cooperation Organization countries	BMA & WALS	FD ≠ REN
Raza et al. (2020)	1997–2017	15 countries	Panel smooth transition regression	U-shaped
Lin et al. (2016)	1980–2011	China	Vector error correction model	FD ↑ REN
Burakov and Freidin (2017)	1990–2014	Russia	Vector error correction model	FD ≠ REN
Best (2017)	1998–2013	137 countries	Panel fixed effect model	FD ↑ REN
Amuakwa-Mensah and Näsström (2022)	1998–2012	124 countries	GMM	FD ↑ REN
Alsagr and van Hemmen (2021)	1996–2015	19 emerging countries	GMM	FD ↑ REN
Asongu and Odhiambo (2021a) and Asongu and Odhiambo (2021b)	2004–2014	39 sub-Saharan African countries	GMM & Panel quantile regresion	FD ↑ REN
Pata et al. (2022)	1980–2019	USA	Quantile Regression	FD ↑ REN
Belaïd et al. (2021)	1984–2014	9 MENA countries	Panel quantile regression	FD ↑ REN
Chang et al. (2022)	2000–2020	China	NARDL	FD ↑ REN
Dimnwobi et al. (2022)	1981–2019	Nigeria	ARDL	FD ↑ REN
Khan, Khan, and Binh (2020)	1980–2018	192 countries	Panel quantile regression	FD ↑ REN
Khezri et al. (2021)	2000–2018	31 Asia-Pacific countries	Spatial regression	FD ↑↓ REN
Mukhtarov et al. (2020)	1993–2015	Azerbaijan	ARDL & VECM	FD ↑ REN
Mukhtarov et al. (2022)	1980–2019	Turkey	ARDL & VECM	FD ↑ REN
Qamruzzaman and Jianguo (2020)	1990–2017	113 countries	Panel NARDL & GMM	FD ↑ REN
Saleem Jabari et al. (2022)	1980–2016	Turkey	Bootstrap ARDL	FD ↑ REN

(Continues)

TABLE 1 (Continued)

Study	Data span	Country	Technique	Findings
Saadaoui (2022)	1990–2018	9 MENA countries	ARDL-PMG	FD↓ ≠ REN
Somoye et al. (2022)	1989–2019	United Arab Emirate	Bootstrap ARDL	FD ↑ REN
Ye et al. (2022)	1976–2020	Pakistan	Error correction model	FD ↑ REN
Yu et al. (2023)	1996–2018	35 countries	Panel OLS & Dynamic panel threshold	FD ↑ REN
Ankrah and Lin (2020)	1980–2015	Ghana	VECM	FD↓REN
Jamshid et al. (2022)	1995–2015	India, Pakistan, Sri Lanka, Nepal & Bangladesh	AMG	FD↓REN
Chireshe (2021)	2000–2016	17 African countries	Fixed effect estimator and System GMM	FD ↑ REN
Kwakwa (2021)	1971–2014	Ghana	ARDL &FMOLS	FD↓REN
Bunyaminu and Yakubu (2022)	1990–2018	Africa	System GMM	FD↓REN
Ndubuisi et al. (2023)	2010–2020	46 African countries	System GMM	FD ↑ REN
Irfan et al. (2023)	1990–2019	G-7 countries and E-7 countries	CS-ARDL, AMG and CCEMG	FD↓REN
Appiah-Otoo et al. (2023)	2000–2018	G-20 countries	GLS and Fixed effect estimator	FD ↑ REN
Prempeh (2023)	1990–2019	Ghana	ARDL, VECM, FMOLS, CCR and DOLS	FD ↑ REN
Muoneke et al. (2023)	2010–2020	46 African countries	System GMM	FD ↑ REN
Akpanke et al. (2023)	1990–2021	15 West African countries	Panel ARDL (PMG, MG & DFE)	FD↓REN
Saadaoui and Chtourou (2022)	1984–2017	Tunisia	NARDL	FD↓REN
Somoye et al. (2023)	1960–2018	Nigeria	Quantile on Quantile Regression	FD↑↓REN
Awijen et al. (2022)	1984–2014	9 MENA countries	Panel smooth transition regression	FD ↑ REN
Somoye et al. (2022)	1960–2019	Nigeria	ARDL & ECM	FD ↑ REN
Saygın and İskenderoğlu (2022)	1990–2015	23 developed countries	GMM	FD↑ ↓REN

Abbreviations: AMG, Augmented Mean Group; ARDL, Autoregressive Distributed Lag; BMA, Bayesian Model Averaging; CCEMG, Common Correlated Effects Mean Group; CS-ARDL, Cross-Section Autoregressive Distributed Lag; DOLS, Dynamic; Ordinary Least Square; ECM, Error Correction Model; FD, Financial Development; GLS, Generalized Least Square; GMM, Generalized Method of Moments; INST, Institutional Quality; LSDV, Least Squares Dummy Variable Estimator; MENA, Middle East and North Africa; MOLS, Fully Modified Ordinary Least Square; NARDL, Nonlinear Autoregressive Distributed Lag; OECD, Organization of Economic Cooperation and Development; OLS, Ordinary least square; PMG, Pooled Mean Group; REN, renewable energy; VAR, vector autoregressive; VECM, vector error correction model; WALS, weighted-average least square.

From the critical review of the literature, as presented in Table 1, it is obvious that studies focusing on Africa are sparse. The available studies are Muoneke et al. (2023) for 46 African countries; Akpanke et al. (2023) for 15 West African countries, Asongu and Odhiambo (2021a), Asongu & Odhiambo, 2021b) for 39 sub-Saharan African countries; Akpanke et al. (2023) for 15 West Africa; Dimnwobi et al. (2022) for Nigeria; Ankrah and Lin (2020) for Ghana; Kwakwa (2021) for Ghana; Prempeh (2023) for Ghana, Saadaoui and Chtourou (2022) for Tunisia; and Somoye et al. (2022) for Nigeria. A critical look at these studies indicates that five consider the country-specific cases of Nigeria, Ghana, and Tunisia. The remaining one focuses on sub-Saharan Africa. This shows the case of Africa has not received adequate attention. Besides, all these studies downplay the moderating role of institutions in influencing the impact of financial development on the renewable energy transition in Africa. This creates a big vacuum in the literature because it has been suggested that the financial system's efficiency in allocating resources to support the switch to clean energy and technology depends on the state of the prevailing institutions. Weak institutions breed corruption and rent-seeking activity, which may sabotage the financial sector's ability to support the transition to environmentally sustainable, renewable energy effectively. The peculiarities of Africa and the challenges posed by the continent's underdeveloped institutions and FD are considered in this study. Because of this, Africa's situation in the global economy is refreshingly unique. Therefore, it will be more suitable to investigate how institutional architectures and FD interplay to influence the transition to REN in Africa.

4.2.2 | Institutional quality and renewable energy

Studies have continued to stress the importance of institutions as crucial ingredients that drive the transition to REN. Institutions are strategic and influential in promoting the deployment of REN, facilitating solutions to environmental problems. There cannot be efficient and laxity-free renewable energy policies without strong institutions. Good institutions bridge the gaps created by environmental policy laxity and energy policy summersaults, which smooth the transition to clean energy and technology. Institutions also enable the efficient allocation of resources to deploy, invest, and produce renewable energy. Institutions also help create the necessary awareness to instill the culture of patronizing renewable energy instead of dominant fossil fuels in developing countries. Viable institutional apparatus tends to incentivize people and educate them on the benefits of clean energy and technology. Due to renewable energy's capacity to decarbonize the economy, researchers have continued to examine the crucial roles that institutions play in supporting the switch to REN.

A comprehensive synopsis of the literature review in Table 2 reveals that studies predominantly support the theoretical proposition that INST is a strong driver of the renewable energy transition. Seventeen of these studies stress the importance of INST as an essential ingredient to propel the transition to renewable energy. Specifically, studies such as Akintande et al. (2020), Asongu and Odhiambo (2021a), Asongu & Odhiambo, 2021b), Belaïd et al. (2021), Baye et al. (2021), Bellakhal et al. (2019), Cadoret and Padovano (2016), Carley (2009), Chen et al. (2021), Mehrara et al. (2015), Saadaoui (2022), Saadaoui and Chtourou (2022), Saygın and İskenderoğlu (2022), Uzar (2020a, 2020b), Wang et al. (2022), and Wu and Broadstock (2015) strongly affirm the instrumentality of INST as a positive driver to stimulate the renewable energy transition. On the contrary, Amoah, Kwablah, et al. (2020) and Opeyemi et al. (2019) are found to be inhibiting the deployment of renewable energy. This indicates that INST supports massive consumption of fossil fuels instead of promoting clean energy that preserves the ecosystem and humanity. The third class of studies establishes an insignificant role of INST in the renewable energy transition (Ergun et al., 2019; Saba & Biyase, 2022). This group plays down the significance of INST in supporting and facilitating clean energy and technology.

A thorough x-ray of the extant literature on the roles of both FD and INST in the renewable energy switch gives some hints and points attention to the lacuna in the existing literature. One, although the literature has suggested the role of FD in the switch to renewable energy. It has been found that the efficiency of FD to spur energy transition depends on INST. More finance without strong institutional policy may not deliver the necessary economic benefits regarding the renewable energy transition. Weak institutions tend to thwart the process by abetting corruption and rent-seeking in the financial system, which diverts credits from clean energy by promoting dirty energy, which deteriorates the environment. It implies that the success of FD will trigger an energy switch. Only two studies (Belaïd et al., 2021; Ndubuisi et al., 2023) have examined the interplay of FD and INST on the path to the renewable energy transition. The study focused on nine MENA countries and sub-Saharan African countries, respectively. It implies that no study captures peculiar features of Africa. Following the discussion in Section 2, particular issues surround the trilogy of institutions, FD, and renewable energy in Africa. Also, this study distinguishes itself from earlier research by determining the INST threshold beyond which institutions provide the necessary support to stimulate FD and spur the renewable energy transition using a dynamic panel threshold. We argue that institutions below the threshold may not be strong enough to prevent fraud, corrupt practices, and the improper allocation of financial resources to fossil fuels that harm the ecosystem and humanity. However, the institutions above the threshold give FD the vital push it needs to hasten the switch to renewable energy.

Africa's case appears appealing; the continent is naturally endowed with abundant renewable energy resources. Meanwhile, the continent is underutilizing its potential for renewable energy resources. Thus, examining the factors that drive the process is very fundamental. African countries have a weak financial system, which may impede the switch to renewable energy. Deployment and production of renewable energy are costly and capital intensive, which requires huge financial resources. To ease the process, a well-functioning financial system is needed. Thus, it becomes imperative to examine the capacities of Africa's financial system to finance the transition to renewable energy effectively. Besides, African institutional development appears weak, which may impede the financial sector's ability to facilitate the energy switch process effectively. As a result, due to its policy implications, examining the moderating roles of institutions in influencing the effect of FD on the renewable energy transition in Africa is very important.

TABLE 2 Studies on the roles of institutional quality in renewable energy transition.

Study	Data Span	Country	Technique	Findings
Mehrara et al. (2015)	1992–2011	9 ECO countries	BMA & WALS	INST ↑ REN
Akintande et al. (2020)	1996–2016	5 African countries	BMA	INST ↑ REN
Asongu and Odhiambo (2021a) and Asongu and Odhiambo (2021b)	2004–2014	39 sub-Saharan African countries	Tobit regression	INST ↑ REN
Baye et al. (2021)	1990–2015	32 sub-Saharan Africa	A bias corrected dynamic panel	INST ↑ REN
Bellakhal et al. (2019)	1996–2013	15 MENA countries	Pooled OLS & Random Effect	INST ↑ REN
Belaïd et al. (2021)	1984–2014	9 MENA countries	Panel quantile regression	INST ↑ REN
Cadoret and Padovano (2016)	2004–2011	26 European countries	LSDV estimator	INST ↑ REN
Carley (2009)	1998–2006	USA	Fixed effect model	INST ↑ REN
Saadaoui (2022)	1990–2018	9 MENA countries	ARDL-PMG	INST ↑ REN
Saadaoui and Chtourou (2022)	1984–2017	Tunisia	NARDL	INST ↑ REN
Saygın and İskenderoğlu (2022)	1990–2015	23 developed countries	GMM & CS-ARDL	INST ↑ REN
Rahman and Sultana (2022)	2002–2019	19 emerging countries	PMG-ARDL	INST↑ REN
Saba and Biyase (2022)	2000–2018	35 European countries	FOLS, DOLS and GMM	INST ≠ REN
Uzar (2020a)	1990–2015	38 countries	ARDL-PMG	INST ↑ REN
Uzar (2020b)	2000–2015	43 countries	ARDL-PMG	INST ↑ REN
Wu and Broadstock (2015)	1990–2010	22 emerging countries	GMM	INST ↑ REN
Akpalu and Wilson (2021)	2000–2015	41 sub-Saharan African countries	GMM	Inverted U-shaped
Amoah, Kwablah, et al. (2020)	1996–2017	32 African countries	DOLS	INST ↓ REN
Opeyemi et al. (2019)	2004–2016	42 sub-Saharan African countries	GMM	INST ↓ REN
Ergun et al. (2019)	1990–2013	21 African countries	GLS	INST ≠ REN
Ndubuisi et al. (2023)	2010–2020	46 African countries	System GMM	INST ↓ REN
Wang et al. (2022)	1997–2019	32 OECD countries	Panel ARDL	INST ↑ REN
Chen et al. (2021)	2005–2015	97 countries	GMM & Dynamic panel threshold	INST ↑ REN
Studies on the Roles of Institutional Quality in the Financial Development-Renewable Energy Nexus				
Belaïd et al. (2021)	1984–2014	9 MENA countries	Panel quantile regression	INST≠FD → REN
Ndubuisi et al. (2023)		46 sub-Saharan African countries	System GMM	INST≠FD → REN

Note: All other acronyms are as defined under Table 1.
Abbreviation: INST, institutional quality.

5 | DESCRIPTION OF THE DATA AND MODELLING PROCEDURES

5.1 | Description and sources of the data

Annual data on thirty-four African countries from 1990 to 2019 are utilized for this study. The list of African countries used in this study is presented in Table A1 (see Appendix). All sub-regions of the African continent are well represented in the sample. The availability of data on key variables determines the selected countries and periods. There is no bias in the choice of countries included in the study. All African countries are the focus, but data availability restricted the sample to 34 countries. We excluded some countries from the study due to insufficient data for the analyzed years.

Meanwhile, all of the African continent's sub-regions, including West Africa, East Africa, Southern Africa, North Africa, and Central Africa, are well represented in this study. As a result, the sample is representative and accounts for all of Africa's distinguishing characteristics. Data on Renewable energy consumption (% of total final energy consumption), real gross domestic product (GDP) per capita (constant 2010 US$), total population and Foreign direct investment, net inflows (% of GDP) are gleaned from World Development Indicator (The World Bank, 2020). Also, data on broad-based financial development (*fd*) indicators are gleaned from International Monetary Fund (IMF) financial statistic Database. The data are more robust and encompassing as it captures the overall performance of both financial markets and institutions. It equally accounts for all the critical dimensions of financial development regarding financial efficiency, access, and depth.

Also, data on institutions are gleaned from International Country Risk Guide (ICRG). This utilizes five institutional quality metrics. Democratic accountability, corruption control, law and order are scaled from 0 to 6 on the ordinal scale of 10, while government stability and bureaucratic quality are scaled from 0 to 12 and 0 to 4, respectively. Following the existing research (Aluko & Ibrahim, 2020a; Law et al., 2013; Law et al., 2018; Muye & Muye, 2017; Olaniyi, 2022; Olaniyi & Adedokun, 2022; Olaniyi & Oladeji, 2021, 2022; Tang et al., 2020), these indicators are rescaled to a scale of 0 to 10. The rescaling is done to enable consistent interpretation and comparison. Institutional measures are also interconnected and strongly linked to one another. The rescaling process is undertaken to allow consistent interpretation and comparison. Furthermore, institutional measures are closely related and tied to one another (Olaniyi, 2022). Studies have shown that these institutional measures work hand in hand to ensure overall institutional development in an economy. The institutional indicators are very intertwined with one another. Thus, examining them independently of one another might not produce the overall effects of institutional architecture on the renewable energy transition in Africa. Following these explanations, the mean of the five institutional quality metrics is obtained to generate the overall index of institutional quality. While values close to 0 imply weak institutions, high values suggest a path toward flawless institutions (Demetriades & Hook Law, 2006; Gazdar & Cherif, 2015; Olaniyi, 2022; Olaniyi & Oladeji, 2021; Olaniyi, Young, et al., 2022; Tang et al., 2020; Uzar, 2020a). We worked hard to extend the study's scope beyond 2019. Data availability on crucial variables such as financial development, institutional quality, and foreign direct investment limited us to 2019. We could not obtain data on institutional quality beyond 2019. Also, this study prioritizes examining how the COVID-19 pandemic may influence the empirical outcome. Meanwhile, our inability to obtain data to cover the pandemic's period restricts the analysis.

5.2 | Methodological procedures

The baseline model for this study starts with the modelling style of extant studies that examine the effects of both FD and INST on renewable energy (Belaïd et al., 2021; Saadaoui, 2022; Saadaoui & Chtourou, 2022; Wu & Broadstock, 2015). Following these studies, other control variables have been confirmed to play roles in the switch to renewable energy options. The model is thus specified:

$$\begin{aligned} ren_{it} = {} & \cap_0 + \emptyset_{it} fd_{it} + \Delta_{it} inst_{it} + \cup_{it} rgdpc_{it} + \forall_{it} fdi_{it} \\ & + \propto_{it} pop_{it} + \gamma_i + \varepsilon_{it}, \end{aligned} \tag{1}$$

where *ren* is the renewable energy consumption, *inst* is the institutional quality, *rgdpc* is the gross domestic product per capita which is a measure of economic growth, *fdi* is the foreign direct investment inflows, and *pop* is the population. The variables of interest in Equation (1) are renewable energy consumption, FD, and INST, while other variables enter as control variables, which are carefully selected following the extant literature. It should be stressed that i indexes the cross-sectional units in the study, and t is the index of time, while γ_i is the peculiarity that is country-specific. The parameters to be estimated in the study are $\emptyset, \Delta, \cup, \forall, and \propto$ while $\cap$ is the intercept or shift parameter.

Equation (1) only gives information on the institution's and FD's linear and direct impacts on renewable while the moderating role is left unexplored. Hence, in tandem with the arguments in previous studies that other variables explain renewable energy's transition, the control variables are carefully incorporated into the model. To capture the moderating role of INST in the way FD spurs the switch to renewable energy, FD and INST interact, and the interactive variable is included in Equation (2) as follows:

$$\begin{aligned} re_{it} = {} & \cap_0 + \emptyset_{it} fd_{it} + \Delta_{it} inst_{it} + \vartheta fd_{it}{}^{*} inst_{it} + \cup_{it} rgdpc_{it} \\ & + \forall_{it} fdi_{it} + \propto_{it} pop_{it} + \gamma_i + \varepsilon_{it}. \end{aligned} \tag{2}$$

Following the inclusion of the interactive variable in Equation (2), the marginal effect of FD on renewable energy is determined given the institutional development in an economy. Consistent with extant studies (Gazdar & Cherif, 2015; Hassan, 2023; Law & Law, 2024;

Olaniyi, 2022; Olaniyi & Oladeji, 2021, 2022; Olaniyi & Olayeni, 2020; Olaniyi, Young, et al., 2022), this is determined by differentiating re_{it} (renewable energy) in Equation (2) partially to fd_{it} (financial development) as follows:

$$\frac{\partial re_{it}}{\partial fd_{it}} = \emptyset_{it} + \vartheta inst_{it}. \quad (3)$$

Equation (3) explains how institutions moderate the influence of FD on renewable energy. The interpretations depend on the signs, magnitudes, and statistical importance of the two estimates $\emptyset$ and ϑ, in the Equation. Recent research has shown that, depending on the level of INST, four plausible explanations could result from the marginal impact of FD on renewable energy. The four possible interpretations of Equation (3) are presented in turn:

a. If $\emptyset > 0$ and $\vartheta > 0$; it implies that FD positively spurs the processes that enable the switch to renewable energy to ensure carbon neutrality of energy usage. Institutional architectures complement finance to provide the essential stimulus that strengthens the positive impacts.
b. If $\emptyset > 0$ and $\vartheta < 0$; the financial sector channels financial resources to activities and investments that enable the switch to renewable energy options and clean technologies that ensure carbon neutrality. The institutional framework weakens the process by tolerating flaws and loopholes, corrupt practices, and rent-seeking activities in the financial system that spur credits to be channelled to environmentally unfriendly ventures and dirty technologies that worsen and deteriorate the environmental quality.
c. If $\emptyset < 0$ and $\vartheta > 0$; this shows that the financial sector's development encourages the financing of dirty, carbon-based technologies that impede the transition to renewable energy and exacerbate the environmental challenges brought on by excessive carbon dioxide emissions. In the meantime, institutional mechanisms lessen the negative consequences of FD by restricting some financial resources to unclean and unsustainable energy sources.
d. If $\emptyset < 0$ and $\vartheta < 0$; these imply that FD hinders the transition to renewable energy by financing and encouraging carbon-intensive production mechanisms and fossil fuel-based technologies. On the other hand, the institutional framework exacerbates the problem by tolerating opportunistic behaviour and rent-seeking activities in the financial system that cause more resources to be channelled into financing dirty technologies and environmentally harmful energy. Hence, financial and institutional developments constitute drags that stunt the renewable energy transition.

Also, following the position of extant studies (Gazdar & Cherif, 2015; Olaniyi, 2022; Olaniyi & Oladeji, 2021), the different signs of the two coefficients and the statistical significance of $\emptyset$ and ϑ in Equation (3) imply the existence of a threshold of INST beyond which FD is strongly spurred to trigger renewable energy transition. The threshold of INST is determined by setting $\frac{\partial re_{it}}{\partial fd_{it}}$ equal to zero in Equation (3). Thus, the threshold is obtained as thus:

$$inst > \left(\frac{-\vartheta}{\emptyset}\right). \quad (4)$$

Consistent with recent developments in empirical research and econometrics, the threshold estimate presented in Equation (4) above has been faulted in the extant studies as static (Olaniyi, 2022; Olaniyi, Young, et al., 2022). A more robust variant that accommodates dynamism and endogeneity in threshold has been introduced. This study uses a dynamic panel threshold in line with the innovative research of Seo and Shin (2016) and Seo et al. (2019). This approach considers econometrics' pitfalls, such as simultaneity bias and endogeneity concerns and carefully accounts for dynamism among the variables (Bolarinwa et al., 2021). The threshold model is presented as follows:

$$re_{it} = \left(1, x_{it}'\right)\alpha_1 1\{inst_{it} \le \delta\} + \left(1, x_{it}'\right)\alpha_2 1\{inst_{it} > \delta\} + \varepsilon_{it}\ \varepsilon_{it} = \gamma_i + v_{it}\ 1 = 1, ..., n; t = 1, ..., T. \quad (5)$$

Renewable energy, re_{it}, is the explained variable in the threshold Equation (5). The dependent variable's lag (re_{it-i}) is included in the vector of control variables known as x_{it} as an independent variable. An indication function is $1\{\cdot\}$. The transitional or threshold variable is $inst_{it}$, and the threshold estimate is δ. The slopes explain regimes 1 and 2. The parameters represent these α_1 and α_2 (Olaniyi, 2022; Olaniyi, Young, et al., 2022). The error term (ε_{it}) is made up of a zero mean idiosyncratic random disturbance (v_{it}) and an unobserved individual country-specific fixed effect (γ_i).

5.3 | Models and estimation procedural processes

In this part, model-related issues and methods for preliminary estimation are discussed. These procedures are essential since they reveal the dataset's fundamental characteristics and determine the estimating algorithms to use.

5.3.1 | Cross-sectional dependence test

Examining the potential existence of cross-sectional dependence in panel analysis has become standard due to recent developments in econometrics and empirical research (Olaniyi, 2023; Dada, Adeiza, et al., 2022; Dada, Olaniyi, et al., 2022; De Hoyos & Sarafidis, 2006; Meo et al., 2020; Olaniyi, 2022; Olaniyi, Young, et al., 2022; Olaniyi, Ojeyinka, et al., 2022). Globalization and cross-border trade have pushed nations to become more interdependent and intertwined. Countries rely on one another for trade and other international interactions since they are not self-sufficient. As a result, shocks could spread from one nation to another. The effect is more substantial among countries within an economic bloc due to the contagion effect and financial integration spur shocks' transmission. Thus, the supposition of cross-sectional independence among countries in panel analysis might not be tenable, and it tends to be cosmetic. Additionally, the macroeconomic and socioeconomic policies and decisions of African countries are strongly interwoven and integrated, making them susceptible to shock transmission in their interactions (Aluko et al., 2021; Dada, Adeiza, et al., 2022; Dada, Olaniyi, et al., 2022; Olaniyi, 2022; Olaniyi, Ojeyinka, et al., 2022; Olaniyi, Young, et al., 2022). Consistent with this trend, this study follows the work of Pesaran (2006) to model cross-sectional dependence as thus:

$$CD = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=0}^{N-1}\sum_{j=i+1}^{N-1}\rho ij\right) N(0,1), \tag{6}$$

where ρij denotes the correlation of errors between cross-sections i and j. This study also examines other CD tests, although the matching models for Baltagi et al. (2012), Breusch and Pagan (1980), Pesaran (2021), and Pesaran et al. (2008) are not provided. Pesaran (2021) and (2004) are used in this study as the baseline model for CD tests.

5.3.2 | Test for slope homogeneity

This sub-section examines whether slope homogeneity occurs across cross-sectional units in tandem with the influential research by Pesaran and Yamagata (2008). This method is favoured above others because, unlike others, it considers cross-sectional dependence when performing the slope homogeneity test. Pesaran and Yamagata (2008) propose their model in two stages. These are adjusted delta tilde and delta tilde, which are stated in the following ways, respectively.

$$\tilde{\Delta} = (N)^{\frac{1}{2}}(2K)^{-\frac{1}{2}}\left(\frac{1}{N}\tilde{S} - k\right), \tag{7}$$

$$\tilde{\Delta}_{adj} = (N)^{\frac{1}{2}}\left(\frac{2k(T-k-1)}{T+1}\right)^{-\frac{1}{2}}\left(\frac{1}{N}\tilde{S} - k\right), \tag{8}$$

where the delta tilde is denoted by $\tilde{\Delta}$ and adjusted delta tilde is denoted by $\tilde{\Delta}_{adj}$. Equation (7) explains the delta tilde, while Equation (8) captures the adjusted delta tilde. The null hypothesis of slope homogeneity, tested against the alternative hypothesis of slope heterogeneity across cross-sectional units, provides the basis for both equations.

5.3.3 | Panel unit root tests

The stationarity properties of the variables are investigated to ensure the deployment of appropriate estimate strategies. Second-generation unit root tests are utilised to forestall the probable existence of CD in the empirical analysis. The recent advances in empirical research have shown that the first-generation unit root tests produce invalid and spurious estimates when there is evidence of CD (Ahmad et al., 2021; Nathaniel, 2021; Olaniyi, Young, et al., 2022; Olaniyi, Ojeyinka, et al., 2022). To ensure the robustness of the findings, this study follows the work of Pesaran (2007) by adopting both Cross-Sectionally Augmented IPS (CIPS) and Cross-Sectionally Augmented Dicky-Fuller (CADF) tests. Meanwhile, it has been established that CIPS gives better outcomes when heterogeneity and CD are present. CIPS also generates more accurate estimates. The CIPS Equation is defined as follows:

$$X_{i,t} = \alpha_i + \alpha_i Y_{i,t-1} + \alpha_i \overline{Y}_{t-1} + \sum_{l=0}^{p}\alpha_{il}\Delta\overline{X}_{t-1} + \sum_{l=0}^{p}\alpha_{il}\Delta X_{i,t-1} + \mu_{it}, \tag{9}$$

where $\overline{X}$ is a representation of the average cross-section of each variable.

The following is a description of the CIPS statistical test:

$$\widehat{CIPS} = N^{-1}\sum_{i=0}^{n} CADF_i. \tag{10}$$

5.3.4 | Cointegration test

A test for potential long-term relationships between the variables is necessary since stationarity features of macroeconomic data typically suggest that the variables are integrated at the level or first difference. The first-generation cointegrating approaches are invalidated by the likelihood of CD in the data (Onifade & Alola, 2022). Second-generation methods function better, address CD, and provide a more reliable long-term relationship, making them a solid choice. Given this concern, Westerlund (2007) is considered to account for CD and endogeneity problems. Compared to other dynamic cointegration techniques, it provides more substantial explanatory power. The test produces four statistics. The first two are the average group statistics which are modelled as follows:

$$G_\tau = \frac{1}{N}\sum_{i=1}^{N}\frac{\widehat{\beta}_i}{SE\left(\widehat{\beta}_i\right)} \text{ and } G_\alpha = \frac{1}{N}\sum_{i=1}^{N}\frac{T\widehat{\beta}_i}{\beta_i(1)}. \tag{11}$$

Equations (11) presents the two statistics to examine the cointegration in the entire panel dataset, while the other two statistics are stated thus:

$$P_\tau = \frac{\widehat{\beta}_i}{SE\left(\widehat{\beta}_i\right)} \text{ and } P_\alpha = T\widehat{\alpha}. \tag{12}$$

These two statistics in Equation (12) explore the possibility of obtaining a cointegration in at least one of the cross-sectional units.

This study employs a variety of estimators to take care of potential econometric and empirical pitfalls that could cast doubt on the validity of inferred policy implications and recommendations to produce accurate estimates that are free of spuriousness. One, a class of estimators such as dynamic system generalized method of moments (SGMM), fully modified ordinary least square (FMOLS), and dynamic ordinary least square (DOLS) are utilized to take care of serial correlation, endogeneity problems, simultaneity bias, and omitted variable bias in panel analysis (Ahmed et al., 2022; Amoah, Kwablah, et al., 2020; Arshad et al., 2020; Bhardwaj et al., 2022; Chandio et al., 2023; Olaniyi, 2019; Olaniyi, 2022; Olaniyi, Obembe, & Oni, 2017; Olaniyi & Oladeji, 2021, 2022; Olaniyi & Olayeni, 2020; Olaniyi, Simon-Oke, et al., 2017; Phillips & Hansen, 1990; Wintoki et al., 2012). However, SGMM, FMOLS, and DOLS do not adequately account for other econometrics constraints. Although these estimators account for endogeneity and serial correlation, they produce invalid results whenever cross-sectional units are dependent (Anser et al., 2021; Dong et al., 2017). Thus, this study considers another group of estimation techniques to ensure robust findings and policy implications.

Two, cross-sectional dependence and heterogeneity are considered pitfalls that must be addressed to deliver reliable estimates in modern panel analyses. Following this trend, the nonparametric covariance matrix estimator developed by Driscoll and Kraay (1998) is deployed. This estimator generates exceptionally reliable standard errors that have high resistance to spatial/cross-sectional dependency, autocorrelation, and heteroscedasticity (Dada, Adeiza, et al., 2022; Driscoll & Kraay, 1998; Hoechle, 2007; Lee & Olasehinde-Williams, 2024; Olaniyi, 2022; Olaniyi, Ojeyinka, et al., 2022; Olaniyi, Young, et al., 2022). Three, to cater to the potential non-stationarities and the cointegration features among the variables, the third category of estimators that deliver long-run estimates and are robust to CD and heterogeneity are utilized. Hence, PMG (pooled mean group), AMG (augmented mean group), and CCEMG (common correlated effects mean group). AMG and CCEMG estimators are adopted because of their peculiar advantages: (i) they do not require testing stationarity properties and cointegration before utilizing them and (ii) the two techniques equally account for CD and slope heterogeneity in panel analysis (Alola et al., 2023; Anser et al., 2021; Chandio et al., 2023; Destek & Sarkodie, 2019; Pesaran, 2006). This study has an advantage in obtaining more reliable and consistent estimates to evaluate the roles of institutional architectures in influencing how FD spurs renewable energy consumption switch in Africa, thanks to an avalanche of estimators such as two-step system GMM, Driscoll and Kraay, FMOLS, DOLS, PMG, AMG, and CCEMG.

6 | PRACTICAL EXPOSITION OF THE ESTIMATES AND FINDINGS

6.1 | Descriptive statistics

To put the study in the right perspective and ensure the correct adoption of the estimation technique, descriptive statistics are examined to reveal the features of each variable. The summary statistics are presented in Table 3. Comparisons of mean values and standard deviation indicate that financial development indicators (*fd*) and foreign direct investment inflows (*fdi*) significantly spread out from their respective mean values. The average values of other variables somewhat represent their actual values. The implication is that other variables aside from *fd* and *fdi* are relatively stable. This signals the necessity of accounting for heterogeneity in the panel dataset. The mentioned variables appear volatile to an extent. The

TABLE 3 Descriptive statistics.

	ren	fd	inst	fd*inst	lrgdppc	fdi	lpop
Mean	3.829	0.137	4.816	0.746	7.127	2.903	16.411
Median	4.359	0.105	4.830	0.494	6.932	1.879	16.553
Maximum	4.588	0.646	8.400	3.643	9.398	40.167	19.119
Minimum	−2.831	0.000	1.000	0.000	5.102	−8.703	13.764
Standard deviation	1.222	0.105	1.048	0.720	1.011	4.474	1.207
Skewness	−2.698	2.361	−0.236	2.126	0.456	3.993	−0.368
Kurtosis	10.597	9.228	3.515	6.984	2.254	26.872	2.549
Jarque-Bera	3690.037	2595.670	20.720	1443.137	58.983	26930.910	31.657
Probability	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	1020	1020	1020	1020	1020	1020	1020

TABLE 4 Correlation.

	1	2	3	4	5	6
ren (1)	1.000					
fd (2)	−0.340***	1.000				
	(0.000)					
inst (3)	−0.230***	0.467***	1.000			
	(0.000)	0.000				
rgdppc (4)	−0.582***	0.550***	0.342***	1.000		
	(0.000)	(0.000)	(0.000)			
fdi (5)	0.139***	−0.017	0.057*	−0.044	1.000	
	(0.000)	(0.598)	(0.071)	(0.161)		
pop (6)	−0.084***	0.121***	−0.111***	−0.203***	−0.017	1.000
	(0.007)	(0.000)	(0.000)	(0.000)	(0.595)	

Note: *** and ** stand for 1% and 5% levels of significance.

coefficient of variation also attests to the results. The variables such as institutional quality (*inst*), population (*lpop*), and renewable energy consumption (*ren*) are negatively skewed while others skew positively. Following Kurtosis's coefficients, four variables are leptokurtic, while the remaining two appear platykurtic. As a result, no variable is mesokurtic. Jarque-Bera statistics also confirm that all variables follow the path of non-normality in data distribution. It implies that data are not symmetrically distributed across the cross-sectional units in the dataset.

The correlation test (see Table 4) among the variables reveals that financial development (*fd*), institutional quality (*inst*), and real gross domestic product per capita (*rgdppc*) are negatively correlated with renewable energy consumption (*ren*), while foreign direct investment (*fdi*) and population (*pop*) are positively correlated with renewable energy consumption (*ren*). Before moving forward with estimations, it is crucial to test for multicollinearity. Multicollinearity in a regression model has the potential to yield wrong conclusions. Strong linear relationships between the independent variables lead to multicollinearity, which inflates the standard errors of the regression coefficients. The Variance Inflation Factor (VIF) test is adopted to identify the presence of multicollinearity. To validate that the multicollinearity problem is not severe, the rule of thumb is that the VIF value must not exceed 10, and the tolerance value must not be lower than 0.1 (Miles, 2014). Consistent with the study of Studenmund (2011), 5 is used as the threshold point for the VIF value. All the VIF values are below 2, and the tolerance values exceed 0.1 (see Table 5). Thus, there is no issue of severe multicollinearity among the independent variables in the model.

6.2 | Slope homogeneity and cross-sectional dependence (CD) tests

Two dimensions of CD tests are adopted to deliver robust empirical estimates, findings, and well-polished decisions.

Four variants of CD tests such as Baltagi et al. (2012), Breusch & Pagan (1980), Pesaran (2021), and Pesaran et al. (2008) are carried out to reveal the presence of CD in each of the series. The results presented in Table 6 validate that substantial evidence of CD in all the variables. This attests to the strong interdependence and intertwining among African countries. Thus, in terms of spillover impacts, African countries are not independent of one another. It also validates the argument that shocks are liable to be transmitted among the nations (Aluko et al., 2021), spatial dependence and a high level of integration exist among African countries due to contagion effects and financial integration (Olaniyi, 2022). It equally suggests that there are actions and reactions among African countries. This indicates there could be moves and countermoves in the macroeconomic policies of African countries. This issue should, therefore, be given adequate attention in analyzing panel data of African countries. There might be spillover effects of macroeconomic decisions and policies from one country to another. Aside from the strong confirmation of CD in the series, the CD is also examined in the regression to ensure the robustness of the findings, and the results are summarized in Table 7. Consistent with the research article of De Hoyos & Sarafdis (2006), three-CD tests, which are Frees (1995), Friedman (1937), and Pesaran (2004), are utilized. All the tests confirm the existence of CD in the regression. Hence, the need to account for CD in the analyses. Following the robust evidence of CD in both the series and regression, the slope homogeneity test is explored via the approach of Pesaran and Yamagata (2008). The results in Table 8 reveal the presence of slope heterogeneity across the countries in the panel dataset.

TABLE 5 VIF test.

	VIF	$\sqrt{VIF}$	Tolerance	R^2
fd	1.83	1.353	0.546	0.454
inst	1.34	1.158	0.746	0.254
rgdppc	1.61	1.269	0.621	0.379
fdi	1.01	1.005	0.990	0.010
pop	1.17	1.082	0.855	0.145
Mean VIF	1.39			

6.3 | Panel unit root and cointegration tests

In tandem with the robust attestation of CD in the series and regression, the first-generation panel unit root tests become inept. Hence, stationarity properties of the variables are tested via second-generation panel unit tests such as CIPS (Cross-sectionally augmented Im, Pesaran, and Shin) and CADF (cross-sectionally augmented Dickey–Fuller). The tests are highly imperative to delivering reliable estimates and guiding the choice of estimators. The results for intercept only and intercept and trend are presented in Tables 9 and 10, respectively. At the level, few variables appear to be non-stationary.

TABLE 6 Cross-sectional dependence tests (in the series).

CD Tests	ren	fd	inst	fd_inst	rgdpc	fdi	pop
Breusch-Pagan LM	5487.003***	4499.685***	3272.327***	4342.955***	8451.832***	1618.079***	16623.130***
Pesaran scaled LM	147.061***	117.586***	80.944***	112.907***	235.574***	31.558***	479.520***
Bias-corrected scaled LM	146.475***	117.000***	80.358***	112.321***	234.987***	30.972***	478.934***
Pesaran CD	51.545***	38.090***	20.897***	29.693***	55.094***	25.000***	128.927***

Note: *** implies that null hypothesis of no cross-sectional dependence is rejected at 1% level of significance.

TABLE 7 Cross-sectional dependence tests (in the regression).

	CD tests		
Model	Peseran CD test	Frees CD test	Friedman CD test
$ren = f(fd, inst, fd^{*} inst, rgdpc, fdi, pop)$	15.831***	5.531*	123.282***

TABLE 8 Pesaran and Yamagata (2008) slope homogeneity test.

Model	$\tilde{\Delta}$	$\tilde{\Delta}_{adj}$
$ren = f(fd, inst, fd^{*} inst, lrgdpc, fdi, lpop)$	−263.543***	−112.375***

Note: *** stands for 1% level of significance.

TABLE 9 Panel unit root tests (intercept only).

Variables	CIPS test Level	CIPS test First difference	CADF test Level	CADF test First difference
ren	−2.456***	−5.236***	−2.132***	−11.629***
fd	−2.711***	−5.527***	−4.459***	−4.052***
inst	−2.628***	−4.946***	−2.991 ***	−4.629***
fd_inst	−2.714***	−5.399***	−2.530***	−4.302***
rgdpc	−1.687	−4.313***	−1.682	−3.330***
fdi	−3.685***	−5.625***	−2.790***	−4.463***
pop	−2.521***	−2.137 ***	−3.610***	−3.403***

***Stands for stationarity at 1% level of significance.

TABLE 10 Panel unit root tests (intercept and trend).

Variables	CIPS Level	CIPS First difference	CADF Level	CADF First difference
ren	−2.462	−5.265 ***	−2.096	−3.762***
fd	−2.618**	−5.724 **	−2.348	−4.241***
inst	−3.381***	−5.092***	−3.587***	−4.654***
fd_inst	−2.930***	−5.487 ***	−2.743***	−4.442***
rgdpc	−1.763	−4.655***	−1.910	−3.778 ***
fdi	−3.874***	−5.647***	−2.991***	−4.450***
pop	−2.874***	−5.362***	−3.254***	−4.519***

Note: ***, ** and * represent 1%, 5% and 10% levels of significance.

TABLE 11 Westerlund ECM panel cointegration tests.

H_o : No Cointegration	Statistic value	Robust *p*-value
G_t	−2.944***	0.000
G_a	−12.381	0.376
P_t	−16.462***	0.000
P_a	−10.884**	0.032

Note: *** and ** denotes 1% and 2% level of significance, respectively. AIC is the chosen lag length criteria.

Meanwhile, all the variables are collectively stationary at the first difference. These mixed orders of integration reveal that the variables might behave divergently in the short run. It is of practical importance to examine if there might be factors to ensure convergence among the variables in the long run (Olaniyi & Adedokun, 2022; Olaniyi & Oladeji, 2022). Due to the strong CD in the dataset, Westerlund (2007)'s cointegration test, which is robust to CD and heterogeneity, is deployed. Following the results in Table 11, the evidence of cointegration is strongly affirmed. This signals a long-run relationship among the variables in the model. This makes it clear that the variables are guaranteed to converge in the long-run path of dynamism. These findings indicate that the long-run estimates are more reliable for policy directions and recommendations. This is suggested as the distortion and divergences among the variables are bound to affect short-run estimates for policy direction. Additionally, the Kao cointegration test confirms that the model's variables have a robust long-run relationship (see Table 12). The two tests confirm the robustness of the cointegration among the variables.

TABLE 12 Koa cointegration test.

	Statistic value	Probability value
ADF	−3.521***	0.000

6.4 | The empirical analysis of the position of institutions in the relationship between financial development and the use of renewable energy

After examining all the required preliminary tests, which reveal the characteristics and features of the dataset and each variable, the emphasis now is on outlining, analyzing, and interpreting key scientific findings. Tables 13–15

TABLE 13 System GMM and Driscoll and Kraay estimators' results.

Dependent variable: ren (Renewable energy consumption)				
Variables	**System GMM estimator**		**Discroll and Kraay estimator**	
ren (−1)	0.986***	0.990***		
	(0.000)	(0.000)		
fd	0.491***	0.441***	0.916**	2.204***
	(0.000)	(0.002)	(0.042)	(0.000)
inst	0.004**	0.006**	0.093**	0.061*
	(0.051)	(0.050)	(0.024)	(0.096)
fd*inst		−0.002**		−0.228***
		(0.042)		(0.000)
lrgdppc	−0.060***	−0.062***	−0.774***	−0.771***
	(0.000)	(0.000)	(0.000)	(0.000)
fdi	−0.003*	−0.002	−0.031***	−0.031***
	(0.080)	(0.217)	(0.000)	(0.000)
lpop	0.006	0.011	−0.234***	−0.240***
	(0.685)	(0.173)	(0.000)	(0.000)
Constant	0.209*	0.209*	13.412***	13.330***
	(0.067)	(0.093)	(0.000)	(0.000)
Specification tests				
P-value of AR(1) test statistics	0.012	0.023		
P-value of AR(1) test statistics	0.213	0.343		
P-value of Sargan test statistics	0.724	0.834		

Note: ***, ** and * stand for 1%, 5% and 10% levels of significance, respectively. Probability values are in ().

TABLE 14 FMOLS and DOLS estimators' results.

Dependent variable: ren (renewable energy consumption)				
Variables	**FMOLS Estimator**		**DOLS Estimator**	
fd	0.533***	0.443***	0.782***	1.742***
	(0.000)	(0.000)	(0.000)	(0.000)
inst	0.458***	0.475***	0.017***	3.831***
	(0.000)	(0.000)	(0.000)	(0.002)
fd*inst		−0.219***		−3.033***
		(0.000)		(0.000)
lrgdppc	−0.299***	−0.308***	−0.128***	−1.776***
	(0.000)	(0.000)	(0.000)	(0.000)
fdi	−0.367***	−0.427***	−0.003***	−0.140**
	(0.000)	(0.000)	(0.000)	(0.033)
lpop	−0.070***	−0.071***	−0.440*	−2.122***
	(0.000)	(0.000)'	(0.070)	(0.001)

Note: ***, ** and * stand for 1%, 5% and 10% levels of significance, respectively. Probability values are in ().

display the total results of all the estimators (two-step system GMM, Driscoll and Kraay, FMOLS, DOLS, PMG, AMG, and CCEMG). Each estimator's results are analyzed in two stages to determine its robustness and the estimates' behaviour due to the moderating role of institutions. First, we examine and present the findings

TABLE 15 PMG, AMG and CCEMG estimators' results.

Dependent variable: ren (renewable energy consumption)						
Variables	**PMG Estimator**		**AMG Estimator**		**CCEMG Estimator**	
fd	0.394***	0.042**	0.007**	0.818**	0.267**	3.692**
	(0.000)	(0.057)	(0.028)	(0.046)	(0.035)	(0.042)
inst	0.003**	0.008**	0.011**	0.016***	0.017**	0.069**
	(0.023)	(0.027)	(0.043)	(0.003)	(0.025)	(0.031)
fd*inst		−0.068**		−0.148***		−0.691***
		(0.016)		(0.000)		(0.004)
lrgdppc	−0.044***	−0.024**	−0.103*	−0.0778**	−0.209**	−0.199*
	(0.001)	(0.041)	(0.081)	(0.031)	(0.047)	(0.072)
fdi	−0.004***	−0.004	−0.001*	−0.001*	−0.001*	−0.005*
	(0.000)	(0.330)	(0.094)	(0.079)	(0.092)	(0.080)
lpop	−0.020**	0.090**	−0.293*	−0.267***	−2.778*	−3.011*
	(0.045)	(0.000)	(0.083)	(0.004)	(0.079)	(0.082)
Constant	−1.152***	−1.617***	9.824***	9.175***	11.889	0.933
	(0.000)	(0.000)	(0.000)	(0.003)	(0.723)	(0.976)
RMSE			0.037	0.036	0.027	0.024

Note: ***, ** and * stand for 1%, 5% and 10% levels of significance respectively. Probability values are in ().

without considering the effect of the interaction between institutional quality and financial development. In the second stage, we interact the two variables to assess how institutions moderate the impact of financial development in accelerating Africa's transition to renewable energy. These seven estimators ensure all the econometrics' pitfalls are circumvented to gain solid findings and policy implications robustness. We utilize GMM, FMOLS, and DOLS to deal with the endogeneity inherent among the variables in the panel data. To deliver more robust empirical outcomes, this study uses Driscoll and Kraay, PMG, AMG, and CCEMG, which are resistant to cross-sectional dependence and heterogeneity. This study uses these estimators to deliver robust estimates with enhanced empirical outcomes and rich policy implications.

According to the results of system GMM in Table 13, the Sargan test validates the used instrumental variables, and the estimates are judged serial correlation-free. Consistent with the previous studies on the determinants of renewable energy, which adopted GMM as an estimator (Akpalu & Wilson, 2021; Alsagr & van Hemmen, 2021; Amuakwa-Mensah & Näsström, 2022; Asongu & Odhiambo, 2021a; Asongu & Odhiambo, 2021b; Brunnschweiler, 2010; Bunyaminu & Yakubu, 2022; Chen et al., 2021; Muoneke et al., 2023; Ndubuisi et al., 2023; Opeyemi et al., 2019; Saygın & İskenderoğlu, 2022; Wu & Broadstock, 2015), we use lag one of ren (renewable energy) as one of the explanatory variables to examine dynamism and persistence (Ehigiamusoe, 2023; Lee & Olasehinde-Williams, 2024) in people's habits towards switching to renewable energy. Also, scholars have justified the adoption of GMM when the orders of integration of the variables do not exceed one (Atasoy, 2021; Breitung, 1997; Chang et al., 2011; Chen et al., 2014; Fatima et al., 2022; Nazneen et al., 2023; Olaniyi, 2019; Olaniyi, Obembe, & Oni, 2017; Olaniyi & Oladeji, 2021; Olaniyi & Olayeni, 2020; Olaniyi, Simon-Oke, et al., 2017; Olaniyi, Young, et al., 2022). It has been proven that system GMM utilizes variables at the level and first-difference to obtain efficient and reliable estimates (Arellano & Bover, 1995; Atasoy, 2021; Blundell & Bond, 1998; Wintoki et al., 2012). Furthermore, the first-difference GMM estimates the model at the first difference, not at level forms. Following the stationarity properties' tests reveal that the orders of integrations do not exceed one; we follow the extant studies by adopting GMM to account for the endogeneity problem inherent in the relationship among the drivers of the renewable energy transition.

Renewable energy consumption at present is significantly and positively influenced by the coefficient of the lagged value of renewable energy consumption $[lren(-1)]$. This demonstrates that prior renewable energy usage in Africa is a powerful motivator that encourages people to develop a habit of consuming more renewable energy and less energy derived from fossil fuels. According to the implication, the policy shift toward carbon-neutral energy in Africa should be more tenacious and cognizant of instilling the culture in people. This serves as a reminder to stakeholders and governmental agencies to be more aggressive in disseminating information about the advantages of switching to renewable energy sources so they can develop an ingrained habit of decarbonizing the African continent. This finding aligns with the research outcomes of Alsagr and van Hemmen (2021), Brunnschweiler (2010), Marques and Fuinhas (2011), Opeyemi et al. (2019), and Ndubuisi et al. (2023), which find that previous consumption of REN has a strong and positive driving force to instill a habit in people to consume more in the current period to stimulate carbon neutrality economy.

All the estimators adopted in this study support FD's positive and significant role in the switch to renewable energies (see Tables 13–15). This implies that financial sectors in African countries have been playing crucial roles in providing financial facilities and credits to support massive investments needed to deploy renewable energy technologies in productive structures and energy consumption patterns to spur the transition to carbon-neutral energy consumption. These research outcomes indicate that the development of the financial sector should be aggressively pursued in Africa, as it is a key factor to spur the renewable energy transition. To decarbonize the African economies, all important financial sector stakeholders should be encouraged to devote more financial resources to advancing renewable energy technology. The finding suggests that the African financial system aids households and businesses in gaining greater access to financial resources and credit opportunities that enhance their businesses and enable them to buy durable goods and assets that eventually lead to a rise in demand for renewable energy. Through the expansion of the financial sector, renewable energy consumption is being deployed, which tends to lower CO_2 emissions into the atmosphere and improve the overall quality of life, ensuring sustainable development in African countries (Xu & Ullah, 2023).

This research's findings follow the theoretical argument that a more advanced financial system encourages and supports adopting renewable energy and technology, which poses a significant obstacle to adopting REN in developing countries, mainly African countries. It implies that more excellent financial sector development in Africa tends to increase the capacity to provide credit facilities to support and finance environmentally friendly technologies at a significantly reduced cost by deploying renewable energy and technology. It should be stressed that stakeholders, policymakers, and energy experts in Africa must keep a vigilant eye on FD as a vital factor capable of spurring the renewable energy switch. The relevance of this conclusion for African nations is that the move to renewable energy is heavily dependent on FD. As a result, major efforts must be undertaken to achieve more advanced FD to support the development of clean technology and energy in Africa. Further development of Africa's financial sector is critical because statistics have shown that SSA, for instance, contributed only 0.3% of the total global investment in REN (IRENA, 2016). This is crucial since previous research has shown that the financial system in Africa, on average, lags behind that in other parts of the world. This finding corroborates the research outcomes of Xu and Ullah (2023), Appiah-Otoo et al. (2023), Prempeh (2023), Akpanke et al. (2023), Sun et al. (2023), Iqbal et al. (2023), Ergun and Rivas (2023), Amuakwa-Mensah and Näsström (2022), Alsagr and van Hemmen (2021), Asongu and Odhiambo (2021b), Barua and Aziz (2022), Belaïd et al. (2021), Chang et al. (2022), Dimnwobi et al. (2022), Khan, Khan, and Binh (2020), Khan, Khan, and Zuojun (2022), Khezri et al. (2021), Mukhtarov et al. (2020), Mukhtarov et al. (2022), Pata et al. (2022), Qamruzzaman and Jianguo (2020), Samour et al. (2022), Saleem Jabari et al. (2022), Wu and Broadstock (2015), Ye et al. (2022), and Yu et al. (2023), which establish FD as a pathway to increase demand for renewable energy. Contrarily, it contradicts the findings of studies by Irfan et al. (2023), Ankrah and Lin (2020), Jamshid et al. (2022), Kwakwa (2021), Saadaoui (2022), Saadaoui and Chtourou (2022), Shahbaz et al. (2018), and Wang et al. (2021) that FD weakens and impedes the transition to renewable energy by encouraging the use of technology and energy based on fossil fuels while simultaneously sapping demand and diffusion of renewable energy and technology.

Another critical factor that determines the transition to renewable energy and clean technology is institutional quality. All the estimators attest to institutional quality's strong and positive roles in propelling an increase in demand for renewable energy consumption in Africa. It suggests that all institutional architectures are essential for the execution of strategies and plans free from dishonest and opportunistic inclinations that could be used effectively to ensure Africa's transition to clean technology and renewable energy sources. This shows that strengthening institutions could prevent easing environmental regulations in African nations. It also helps to control corruption and make it more difficult for non-renewable energy companies to thwart investments in renewable energy from parastatals and government agencies through lobbying and other unfair tactics. It also demonstrates how improving political stability, bureaucratic efficiency, democratic transparency, and law-and-order could support environmental awareness campaigns and provide incentives for increasing the use of renewable energy by households and clean technology in African productive bases and industrial structures. It also suggests that institutional architectures and apparatuses could be strengthened to incentivize and enlighten Africans on the need for more renewable energy and technology. It equally implies that more institutional support should be provided to facilitate the allocation of resources to renewable energy production and investment in African countries. The findings corroborate the theoretical proposition of law-and-finance theory, which emphasizes the vital roles of institutions in combating corruption and rent-seeking that could impede the renewable energy transition.

The finding's implications reveal that institutional infrastructures that African countries develop or fail to develop could make or mar the quest to transition to renewable energy. This research output is consistent with the studies of Akintande et al. (2020), Asongu and Odhiambo (2021b), Baye et al. (2021), Bellakhal et al. (2019), Belaïd et al. (2021), Cadoret and Padovano (2016), Carley (2009), Mehrara et al. (2015), Rahman and Sultana (2022), Saadaoui (2022), Saadaoui and Chtourou (2022), Saygın and İskenderoğlu (2022), Sequeira and Santos (2018), Uzar (2020b), and Wu and Broadstock (2015), which attribute the success of renewable energy transition policies and programmes to various institutional factors that block corrupt practices, rent-seeking activities, and opportunistic behaviour. This points out that institutional developments are fundamental to the renewable energy transition in Africa. Contrarily, it stands incongruent with the research output of Akpalu and Wilson (2021), Amoah, Kwablah, et al. (2020), and Opeyemi et al. (2019), which establish that institutions create loopholes and flaws which are instrumental to corruption in the financial system, which culminates in financing fossil fuel-based energy consumption at the expense of renewable energy and technology. It is equally incongruent with some research findings, which find an inconsequential effect of INST on renewable energy's switch (Ergun et al., 2019). Having established FD and INST as separate positive drivers that spur renewable energy transition in Africa, the two variables are interacted to see how they interplay to influence the demand and use of REN.

In all of the estimators used in the analysis, the estimates of the interactive term between finance and institution ($fd^{*}inst$) are consistently significant and negative (see Tables 13–15). This finding suggests that weak institutions in African countries allow financial sector stakeholders to direct resources toward initiatives that support fossil fuel consumption and production. This process hinders the transition to renewable energy, which protects the environment. This move raises carbon dioxide emissions and endangers humanity's sanity and the African ecosystem. That indicates that the institutional framework deteriorates and becomes a drag on Africa's financial system's ability to expedite the transition to renewable energy. Because of the prevalent corruption and weak institutions in African countries, the financial sector is incentivized to channel credit facilities and loan schemes that encourage fossil fuel-based energy technology and consumption. It demonstrates how, while the financial sector directs resources toward initiatives and investments that enable the switch to renewable energy sources and clean technologies that ensure carbon neutrality, the institutional framework undermines the process by tolerating flaws and loopholes, corrupt business practices, and rent-seeking activities in the financial system that encourage credits to be channeled toward environmentally unfriendly activities and dirty technologies that worsen and deteriorate the quality of the environment.

A switch to REN is thwarted and sabotaged by Africa's weak institutional architecture, which encourages opportunistic behaviour and shrewd financial system practices. These practices divert financial resources to support and finance environmentally damaging economic activities and technologies, which sap the demand for renewable energy in African countries. The implications of these findings reveal that INST and FD are not complementary to each other on the path to ensuring the renewable energy transition in Africa. It implies that weak institutions allow loopholes and corrupt dealings in the financial system, which drain some of the positive benefits of FD to spur the switch to renewable energy and green technology in Africa. These findings are not completely surprising, as they confirm the negative effect of the weak state of INST in African countries. It signals the need to block inherent fundamental flaws and lapses in the institutional architecture that breed corruption and opportunistic behaviour in the financial system and thwart the switch to renewable energy and green technology in Africa. This reaffirms that the potency of FD to spur an effective transition to renewable energy depends on the level of institutional development in an economy. Another implication of this finding is that most African countries may not have reached the level of institutional development needed to stimulate FD to spur the switch to renewable energy. These findings emphasize the importance of determining whether Africa's countries are operating below a certain level of institutional quality, above which institutions are strong enough to provide the necessary support and finance to strengthen the financial sector's ability to accelerate Africa's transition to renewable energy. This situation might have given room to inherent weaknesses in the financial system, which allowed credit to be diverted from renewable energy options. The study's findings corroborate the research outcomes of Belaïd et al. (2021), which establishes that INST weakens the spurring power of FD to stimulate renewable energy transition. It equally supports the work of Ndubuisi et al. (2023), which establishes that institutional quality creates loopholes that sap the ability of the financial sector to accelerate Africa's renewable energy transition.

Concerning the control variables, the real income per capita (real GDP per capita, *rgdppc*) coefficients are significant but negatively signed in all the estimators. This suggests that the demand for renewable energy usage declines as income rises. The greater economic prosperity of Africans does not lead to increased demand for renewable energy. The outcome appears to be at odds with conventional wisdom. The consumption of renewable energy is predicted to increase as income levels grow. The example of Africa demonstrates how, as incomes rise, an increase in energy demand may favour non-renewable energies at the expense of green technologies and renewable energy. This might signal that an average African does not know the importance of switching to renewable energy. The outcome is consistent with Ergun et al. (2019), Ergun and Rivas (2023), Shahbaz et al. (2021), Uzar (2020a), and other researchers' findings. Meanwhile, it stands incongruent with the studies of Belaïd et al. (2021), Dimnwobi et al. (2022), Ibrahiem and Hanafy (2021), Jamshid et al. (2022), Sadorsky (2009), Oluoch et al. (2021), Polcyn et al. (2022), Saadaoui (2022), Saadaoui and Chtourou (2022), Samour et al. (2022), and Somoye et al. (2022) which establish income as a positive driver of renewable energy. Another control variable in the study is foreign direct investment (*fdi*). The estimate of *fdi* is persistently negative in all the estimators. Meanwhile, it shows that it is insignificant in a few cases. Thus, it shows that foreign direct investment is a strong negative driver of the renewable energy transition in Africa. It implies that *fdi* inflows to African countries adopting technologies that rely heavily on non-renewable energy at the expense of renewables. This reveals that *fdi* inflows to Africa have not helped the transition to renewable energy. This might suggest that lax environmental quality laws in African countries make them attract highly polluting foreign direct investments from foreign countries, which promote dirty technologies and fossil fuel-based energy consumption. The inflows of *fdi* to African countries mainly attract technology transfer that promotes dirty energy consumption and production. This contradicts the theoretical standpoint, which posits that *fdi* is a major route through which developing countries benefit from technology transfers and the expansion of renewable energy capacity and clean technology. This finding corroborates the study of Alsagr and van Hemmen (2021), Anton and Nucu (2020), Caglar (2020), and Jamshid et al. (2022) while it stands incongruent with Akpanke et al. (2023), Belaïd et al. (2021) and Doytch and Narayan (2016). These studies affirm that *fdi* discourages the use of dirty energy and technology by transferring advanced technologies to developing countries.

All the estimators' findings, except system GMM, indicate that the population (*lpop*) has a negative impact on Africa's efforts to switch to renewable energy. This shows that the demand for renewable energy and technologies falls as the population grows. According to the study's findings, Africa's rapid population increase expands the use of fossil fuel-based energy at the expense of renewable sources. Despite the continent's abundance of renewable energy resources, the growing population in Africa hinders the transition to renewable energy and technologies. To ensure carbon-neutral economies, government organizations and African parastatals must launch extensive campaigns and raise public awareness about the advantages of switching to renewable energy and green technology. This research outcome does not stand alone but aligns with the studies of Bourcet (2020), da Silva et al. (2018), and Ibrahiem and Hanafy (2021). Meanwhile, it contradicts the findings of Akintande et al. (2020) and Nyiwul (2017), which show that *fdi* supports the transition to renewables (both in terms of technology and consumption).

After establishing the significance of institutions in influencing how FD affects Africa's transition to renewable energy, the focus is now on the institutional quality threshold in the nexus. Following the works of Aluko (2020), Bolarinwa et al. (2021), Olaniyi (2022), Olaniyi, Young, et al. (2022)), and Seo et al. (2019) the estimates of a robust dynamic panel threshold of the institution beyond which FD is significantly stimulated to spur the switch to renewable energy in Africa are presented in Table 16. The linearity test is performed under the null hypothesis that a threshold is absent. This hypothesis is rejected by the bootstrapped p-value at the 1% significance level, which attests to nonlinearity and an institutional quality threshold in the relationship between FD and REN in Africa. The institutional quality threshold is estimated to be 4.890. The implication is that before INST can strongly stimulate FD to facilitate the switch to renewable energy, it must consistently be above 4.89 on the ordinal scale of 10. This shows that an institutional quality of less than 4.89 is too weak and leads to financial system flaws. The averaged value of institutional quality for the continent is 4.82. It implies that institutional development in Africa is below the threshold value, over which institutions can prevent rent-seeking and opportunism in the financial system and stimulate financial development to drive Africa's transition to renewable energy positively. As a result, the institutional framework

TABLE 16 Results of dynamic panel threshold estimate of Institutional quality.

Dependent variable: lren (Renewable energy consumption)	
	Threshold variable: inst (Institutional quality)
Threshold value of institution	4.890*** (0.000)
Linearity test (Bootstrapped *p*-value)	0.000***
Constant	2.217*** (0.041)
	Lower regime ($q_{it} \leq \delta$)
Lagged lren	0.661 *** (0.000)
fd	1.700*** (0.002)
inst	−0.074*** (0.004)
lrgdppc	−0.242*** (0.004)
fdi	0.001 (0.591)
lpop	0.174 (0.051)
	Upper regime ($q_{it} > \delta$)
Lagged lren	−0.146*** (0.001)
fd	−2.774*** (0.00)
inst	0.096*** (0.001)
lrgdppc	−0.077 (0.101)
fdi	0.005*** (0.005)
lpop	−0.078 (0.132)

Note: ***, ** and * represent 1%, 5%, and 10% levels of significance respectively. Probability values are reported in parentheses. 1000 bootstrap iterations are used to compute the bootstrapped *p*-values.

encourages unethical practices, corruption, and opportunistic behaviour in Africa's financial system, which diverts credit resources and funding to obstruct the continent's transition to renewable energy. On the contrary, institutional quality persistently above 4.89 tends to prevent the financial system's inherent weaknesses and lapses, which are liable to assist in channelling financial resources to finance renewable energy production and investment, which boosts the effort to enable Africa's energy transition.

The findings reveal that the average institutional quality values are below the estimated threshold in 18 countries (Angola, Burkina Faso, Cameroon, Côte d'Ivoire, Congo Republic, Democratic Republic of Congo, Ethiopia, Gabon, Guinea, Guinea-Bissau, Libya, Mali, Niger, Nigeria, Sierra Leone, Sudan, Togo, and Uganda). While they are above the estimated threshold in 16 countries (Mozambique, Malawi, Algeria, Zambia, Egypt, Senegal, Kenya, Kenya, Madagascar, Ghana, Gambia, Tunisia, South Africa, Botswana, Namibia, and Morocco), marginally above the threshold. The statistical findings from the raw data show that institutional development is not persistent in African countries that exceed the threshold. It frequently exhibits unpredictable behaviour. The inconsistencies in institutional development are bound to drag the process and investment in producing and consuming renewable energy in Africa. Due to this, the institutional framework in those countries might not be able to effectively play the function of facilitating FD to enable the renewable energy transition. This reveals why Africa's institutions abet opportunistic behaviour and corruption, which divert credit facilities to finance dirty energy and technology and thwart the renewable energy switch. The research outcomes imply that African countries must make concerted efforts to simultaneously pursue both institutional and financial development to enable the renewable energy transition. In specific terms, the institutional framework guiding the channelization of resources from the financial system to support the transition to renewable energy in African countries should be critically evaluated to eliminate diversion and opportunism, which further promote the growth of dirty energy consumption and technology.

Within the context of the dynamic panel threshold, the estimates of variables are presented for the two regimes (lower and upper). The lower regime presents the estimates before the threshold is attained, while the upper regime presents the estimates after the threshold has been attained. The results reveal that INST is significant and negative before the threshold is attained, while this changes to positive after reaching the upper regime. It equally supports the position raised earlier that African countries have to make serious efforts to develop the financial sector and institutional development to drive home the switch to renewable energy. Without a matching improvement in INST in Africa, deploying clean technology and renewable energy through FD is susceptible to being undermined. Overall, it seems that INST is now too weak and riddled with flaws to allow for the significant influence of financial sector development in the transition to renewable energy. Institutional development below the threshold could breed opportunistic behaviour, corruption, and flaws in the financial system, which will likely hinder Africa's transition to clean technology and renewable energy sources.

7 | PRACTICAL CONTRIBUTIONS AND POLICY RECOMMENDATIONS

This study provides novel insights into the theoretical understanding of the link between financial development and renewable energy. The theoretical proposition highlights the importance of augmenting economic theories that explain different channels through which financial development spurs the growth of renewable energy with the law-and-finance theory. This theory bridges the inherent and unexplained lapses and gaps in the nexus to highlight how institutions moderate and influence the transmission of financial development to spur the switch to renewable energy. The merging of these theories reveals that a well-developed financial system without efficient institutions may not succeed in accelerating the renewable energy transition. This proposition explains that inefficient institutions breed loopholes and opportunistic behaviour in the financial system, which thwart the transition to renewable energy. This work has significantly added to the knowledge of how institutions influence the relationship between FD and the shift to renewable energy sources. One, this study is the maiden attempt to establish the institutional quality threshold in the FD-renewable energy nexus using a robust dynamic panel threshold. Two, the study presents the first empirical effort to examine how institutional architecture and financial sector development interact to spur the renewable energy transition in Africa. Three, it provides more robust empirical analyses by adopting seven different estimators to deal with the observed econometric pitfalls within the context of both first-and-second-generation techniques. Four, the study demonstrates the critical roles financial and institutional development play in facilitating Africa's transition to renewable energy. Five, it provides novel and insightful policy dimensions using the interaction between INST and FD to ease the transition to renewable energy to decarbonize the ecosystem and improve human welfare in Africa. Sixth, this study has shown that if it is appropriately managed, institutional quality is a major macroeconomic variable policy that can enhance the financial sector's performance and efficiency to facilitate the production of clean energy and Africa's transition to renewable energy.

The empirical results lead to the following policy implications and recommendations from a policy perspective: One, the fact that past use of renewable energy has had a substantial positive impact on current use suggests that parastatals, government organizations, and energy specialists in African nations must work tirelessly to develop in people culture and habit of using clean technology and energy. To instill in Africans the habit of switching to renewable energy consumption and clean technology, persistent, massive, and aggressive campaigns, awareness-raising efforts, and knowledge transmission on the benefits of clean energy should be undertaken. African governments should create inducements and incentives for citizens and business owners to develop the habit of using clean energy and consuming fewer fossil fuels and technologies. Two, financial development in terms of efficiency, depth, and accessibility must be prioritized in the developmental agenda to decarbonize the continent by switching to renewable energy and clean technology in African countries. To fully utilize the abundant renewable energy potential of the continent, stakeholders must make serious efforts to achieve higher financial sector development that focuses on channelling credit facilities and financial resources to investment and the production of renewable energy. More financial resources from the financial system to households and business owners to finance more renewables should be encouraged. This tends to create a high demand for renewable energy. It also enables a gradual transition to carbon-neutral energy and technology in Africa.

Three, there should be concerted efforts to build up institutional architecture that is central to Africa's transition to renewable energy. This is meant to firm up institutions to rid of corruption, deceitful practices, and rent-seeking activities that could thwart the strategic plans and policies, as well as efforts to spur Africa's transition to renewable and clean technology to preserve the sanctity of the ecosystem and human lives. Also, further institutional development should be made a priority in Africa. The majority of African countries operate below the institutional development threshold that is necessary to effectively and strongly catalyze the renewable energy transition in Africa. It signals weak institutional quality which could breed corrupt practices and opportunistic inclinations that might impair resources allocation to investment and production of renewable energy and technology. Four, institutional structures within which Africa's financial system operates must be completely remodeled and carefully monitored since poor institutional quality saps the advantages of FD that support the transition to renewable energy sources. To the detriment of renewable energy, it appears that weak institutions have enabled financial system flaws and loopholes that encourage and support the use of dirty technology and fossil fuel-based energy. Therefore, mechanisms and specific apparatuses must be put in place to checkmate the institutions weakening the positive driving force of FD to accelerate the transition to REN in Africa. Five, African governments and all public institutions should design multidimensional incentives and inducements for financial sector stakeholders to channel more financial resources and credit facilities to long-term and sustainable investments in renewable energy. Six, Governments at all levels in Africa should encourage the financial sector to design soft loans for individuals and households willing to embrace renewable energy options. This scheme will enable African citizens to consume more renewable and less dirty or fossil energy. Also, there should be more liberal policies in Africa's financial system geared and tailored towards committing the financial sector stakeholders to support the moves to accelerate the switch to renewable energy options.

8 | SUMMARY AND CONCLUSION

The sustainable development goals (SDGs) number 7, 8, 11, 12, and 13 of the United Nations Development Programmes (UNDP) are congruent with achieving environmental sustainability and switching from fossil fuel-based energy consumption to clean energy (renewable energy) to decarbonize the global economy, ecosystem, and preserve mankind. Globally, countries and regions have embraced these lofty objectives, and current literature has remained dominated by empirical research in this area. Existing research has identified FD and INST as crucial drivers that spur the transition to clean technology and renewable energy (REN). It has been argued that the renewable energy transition relies heavily on FD. Renewable energy production and investment require huge amounts of capital and high-powered infrastructure. The transition to renewable energy sources must be financed, which calls for developing a robust financial system to ease these huge financial burdens.

Meanwhile, it has equally been elucidated that the effective role of FD in the transitioning process depends on the INST. Weak institutions breed corruption, rent-seeking activities, and opportunistic behaviour in the financial system. This, therefore, thwarts the transition process to REN and clean technology. As a result, an economy's institutional quality determines how important FD is to the shift to REN. Following this proposition, it implies that FD and institutional architecture interact to determine the switch to renewable energy. Many studies examine the direct effects of FD and INST on renewable energy, with mixed and conflicting findings. However, there is inadequate research on the roles of the interplay between FD and institutions in the renewable energy transition. The only study on this issue focuses on nine MENA countries. The findings and policy implications cannot be used to generalize for other continents and regions. A study that uses data on the continent to examine how FD and INST interact to support the transition to REN in Africa does not yet exist, despite the continent having abundant renewable resources and weak financial and institutional development. Similarly, this study makes the first effort to add to the larger discussion by making the case that institutions may need to reach a specific threshold before institutions can effectively support FD to accelerate the switch to REN. The level of institutions before the threshold is attained might be too weak and breed corruption in the financial system to hinder the switch to renewable energy.

Annual data from thirty-four African countries are utilized for the period 1990–2019. To ensure robust empirical analyses, seven estimators within first- and second-generation techniques are utilized to deal with the potential econometrics' pitfalls. The estimators adopted are a two-step system generalized method of moments (GMM), fully modified ordinary least square (FMOLS), dynamic ordinary least square (DOLS), pooled mean group (PMG), Driscoll and Kraay's nonparametric covariance matrix, augmented mean group (AMG), and common correlated effects mean group (CCEMG). The research outcomes robustly reveal that both FD and INST are significantly instrumental to the renewable energy transition in Africa. Thus, relevant stakeholders and policymakers will explore and utilise the two factors objectively and appropriately to drive the switch to REN on the continent.

Meanwhile, the interaction between FD and INST in driving the transitional process to REN in Africa is significantly negative. It implies that, as financial sector development facilitates the transition by providing necessary stimulus in terms of support and finance to increase renewable energy investment and production, institutional architecture constitutes a drag by creating loopholes that abet sharp practices and rent-seeking in the financial sector that also divert some of the credit facilities meant to promote REN. Due to this, using environmentally damaging technology and fossil fuel-based energy may have increased at the expense of renewable sources. Thus, Africa's transition to REN may have been impeded by institutional flaws that drove FD in the wrong direction. The research also shows that institutional development in most African countries is far below the threshold for institutions to strongly encourage FD to accelerate the switch to renewable energy sources. This highlights the lack of strong institutions in Africa and confirms and reaffirms the role of institutions as substitutes in FD as we move toward a renewable energy paradigm.

From a policy perspective, the study's conclusions have several policy implications that are bound to encourage the expansion of production and consumption of REN in the African context. One, there should be improvements and development in INST and FD. Practical steps should be taken to improve regulatory apparatuses, bureaucratic quality, legal framework, and political system to accelerate the transition to REN and put the African continent on a path of sustainable development. Two, the pace of FD in Africa must improve to promote and encourage renewable energy production and investment. This will make credit facilities more accessible at a very reduced cost to households and firms engaged in renewable energy production and investment in Africa. Three, a thorough analysis and review of the institutional setting and environments that regulate Africa's financial system are required. It will make it easier to identify and fix any flaws and loopholes that divert resources away from producing and using renewable energy sources. Four, concrete steps should be taken by stakeholders and policymakers to achieve complementarities in the development of Africa's financial and institutional development in order to genuinely accelerate the continent's transition to renewable energy. The results show that FD's ability to play its part in the transitioning process is hindered by INST. Thus, the two determining factors must develop concurrently and complementarily to ensure an effective energy transition in Africa.

9 | LIMITATIONS OF THE STUDY AND SUGGESTIONS FOR FUTURE RESEARCH

This study has the edge over the extant studies in the finance-institution-renewable energy trilogy by establishing the institution's threshold beyond which FD is significantly enhanced to spur the renewable energy transition. However, other areas that have not been examined could be explored in the subsequent research efforts by other scholars. One, other scholars are encouraged to explore the nexus within the context of time series to account for country-specific particularities, which tend to give a more pragmatic policy perspective. Two, following the establishment of income as a non-compliant factor to spur Africa's switch to clean energy in all estimators, future research efforts should add glitter to our empirical findings by categorizing African countries into different income groups such as low-income, lower-middle-income, and upper-middle-income. These classifications should be based on per capita income, as recommended by the World Bank. This endeavour will provide additional insights into the significance of income as a factor in Africa's drive for the renewable energy transition. Three, data non-availability has caused this study to reduce the number of African countries covered to thirty-four. Other researchers are urged to re-examine the nexus for the entire continent in future research efforts. Four, it will be an added advantage if subsequent research efforts could evaluate the influence of the COVID-19 pandemic on Africa's move to spur the transition to renewable energy. We could not address this aspect because the data availability for the period constitutes a restriction. The research findings have not been compromised in any way by the limitations that have been identified. We raise these limitations in anticipation of continuing research exploits centred on Africa's renewable energy transition to gain further insights and policy implications.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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APPENDIX A

TABLE A1 The list of African countries covered in the study.

Algeria	Gabon	Morocco	Togo
Angola	Gambia, The	Mozambique	Tunisia
Botswana	Ghana	Namibia	Uganda
Burkina Faso	Guinea	Niger	Zambia
Cameroon	Guinea-Bissau	Nigeria	
Congo, Dem. Rep	Kenya	Senegal	
Congo, Rep	Libya	Sierra Leone	
Côte d'Ivoire	Madagascar	South Africa	
Egypt	Malawi	Sudan	
Ethiopia	Mali	Tanzania	