Threshold Effects of Climate Financing on Renewable Energy Capacity in Nigeria

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https://doi.org/10.56201/ijebm.vol.12.no11.2026.pg73.91

Abstract
This study examined the relationship between climate finance mechanisms and renewable energy capacity growth in Nigeria from 2010Q1 to 2025Q4. The specific objectives were to assess the effects of green commercial loans, green bond issuances, foreign direct investment in cleantech, and international climate aid and grants on renewable energy capacity growth, while controlling for the influence of inflation. The study adopted a quantitative ex-post facto research design and employed Discrete Threshold Regression analysis. Data were sourced from the Central Bank of Nigeria, Securities and Exchange Commission, Nigerian Exchange Limited, National Council on Climate Change, Green Climate Fund, World Bank Development Indicators, and International Renewable Energy Agency. The findings revealed that all four climate finance mechanisms have significant effects on renewable energy capacity growth, characterized by nonlinearities and threshold effects. Green commercial loans exhibited three regimes with thresholds at 0.90 and 8.70 million dollars. Foreign direct investment in cleantech showed four regimes with thresholds at 10.40, 38.50, and 68.40 million dollars. International climate aid exhibited three regimes with thresholds at 78.50 and 192.50 million dollars. Green bond issuances demonstrated a consistently positive and significant effect, with each million-dollar increase contributing approximately 0.067 megawatts to renewable energy capacity growth. The study recommends among others that Central Bank of Nigeria and financial regulatory authorities should implement policies to scale up green commercial lending through green lending mandates, preferential reserve requirements, and capacity building programs for financial institutions to achieve the critical mass necessary for transformative renewable energy capacity growth.

Key words: *Climate finance; Renewable energy capacity growth*

1. Introduction

Nigeria stands at a critical juncture where the existential threat of climate change converges with a transformative economic opportunity. As Africa's largest economy and most populous nation, with over 230 million people, Nigeria is both profoundly vulnerable to climate impacts and uniquely positioned to become a continental leader in the global green economy (Onyekachi, Ihuoma, Ojiugo, & Nnamdi, 2025). The country's challenge is twofold: it must address the devastating consequences of extreme weather, flooding, land degradation, and food insecurity

that already displace and impoverish millions, while simultaneously pursuing a sustainable development pathway beyond its traditional reliance on fossil fuels (Onyekachi Amarachi et al., 2025). This dual imperative has placed climate finance and green investment at the heart of national policy discourse, as Nigeria seeks to translate ambitious environmental pledges into tangible, bankable projects that can drive economic growth, create jobs, and build climate resilience (Pat-Natson, Nwankwo, Udeh, Obi, & Okoye, 2025). Yet the financing gap remains stark: Nigeria's updated Nationally Determined Contribution (NDC) estimates a requirement of approximately USD 177 billion by 2030, while current public and private investments fall far below this threshold (Pat-Natson et al., 2025). This persistent gap raises critical questions about the effectiveness, accessibility, and suitability of climate finance mechanisms for the Nigerian context, particularly given the structural and institutional constraints that limit the country's ability to mobilize, absorb, and track such finance effectively (Abubakar, 2025).

A robust legislative and institutional framework is being established to underpin this transition. The Climate Change Act of 2021 provides a legal architecture for climate governance, carbon budgeting, and emissions reporting (Umeh, Nwankwo, Oluka, Umeh, & Ogbonnaya, 2024), while the Electricity Act of 2023 enables greater decentralisation and empowers states to develop their own electricity markets a critical reform given that only 57% of the population has access to electricity, with a mere 35% reliability rate (Samuel et al., 2025). Complementing these legislative advances, the National Council on Climate Change is developing a National Carbon Market Framework, and the Net Zero Investment Plan (NZIP) is designed to convert Nigeria's climate commitments into a pipeline of bankable investment opportunities across priority sectors including power, transport, agriculture, waste management, industry, and domestic energy, with the broader aim of achieving net zero emissions by 2060 at an estimated investment of $1.9 trillion (Federal Radio Corporation of Nigeria, 2026). Among the most notable financial instruments are sovereign green bonds (SGBs), which enable governments to raise capital for national climate and sustainability objectives (Samuel Owusu-Mante, Kim-Hung Kwong Chi, and Thirumaran Gopalakrishnan, 2025). Nigeria's inaugural green bond in 2017 raised 10.6 billion naira for renewable energy and afforestation projects, and its second issuance received an order book of NGN 32.93 billion, representing 2.2 times the NGN 15 billion initially offered. Quantitative analysis of green bond issuances for renewable energy in Nigeria from 2017 to 2024 reveals a steady increase in issuance volume, with sovereign issuances reaching USD 107.6 million in 2022 and corporate issuances totaling USD 87.4 million in 2021; these instruments have contributed approximately USD 1.2 billion to total renewable investments with mean internal rates of return of 14.3% (Samuel et al., 2025). Despite these advances, Nigeria's acute climate vulnerability continues to shape and constrain its investment landscape. Recurring and devastating floods have displaced millions, destroyed farmlands and infrastructure, and intensified concerns about food insecurity, while desertification in the north and coastal erosion in the south threaten livelihoods and communities, making climate adaptation not merely an environmental necessity but a critical component of national security and economic survival (Onyekachi et al., 2025). Empirical evidence confirms that FDI inflows are negatively affected by climate vulnerability indices, and that the adverse influence of climate change vulnerability on inward FDI becomes more pronounced when climate readiness is poor (Fagbemi et al., 2025). This implies that in the absence of macro-critical policies that could stimulate quick action to climate shocks, the negative effects of vulnerability on FDI would be further escalated. At the same time, Nigeria possesses extensive renewable energy resources, including 427 GW of solar potential, 14 GW of wind, 3.5 GW of hydroelectric capacity, and significant biomass resources;

however, less than 2% of electricity supply comes from renewables excluding traditional biomass (Umeh et al., 2024). Existing barriers include scarce financing, weak policy frameworks, perception gaps, skill gaps, underdeveloped supply chains, and workforce gaps, while regional bias in investment flow remains evident, with the southwest zone receiving the lion's share of 68% of investments (Samuel et al., 2025). Beyond energy, climate-smart agriculture offers significant prospects for enhancing food security while building resilience against drought and desertification (Onyekachi et al., 2025), and sustainable transportation which accounts for 24% of Nigeria's total greenhouse gas emissions represents another critical sector for decarbonization (Africa Policy Research Institute, 2025). Nigeria's pursuit of climate finance and green investment is characterised by a comprehensive and multi-layered strategy confronting its climate vulnerabilities with a policy mix that ranges from groundbreaking legislation to the creation of sophisticated financial instruments (Abubakar et al., 2025; Pat-Natson et al., 2025). The country is actively moving from policy formulation to implementation, seeking to build an ecosystem where climate action is seen not as a cost, but as a fundamental driver of sustainable economic development and shared prosperity (Federal Radio Corporation of Nigeria, 2026). However, unlocking climate finance at scale will require coordinated institutional reforms, strengthened monitoring, reporting and verification (MRV) infrastructure, a unified national climate-finance framework, and strategic engagement with Article 6 carbon markets and blended-finance opportunities (Abubakar, 2025). These reforms are critical not only for meeting Nigeria's mitigation and adaptation commitments but also for safeguarding long-term climate-resilient development in a country where climate change vulnerability and economic prosperity are inextricably linked. The remainder of the study is organized into a logical sequence. Following this introduction, the subsequent section reviewed the relevant theoretical background and empirical literature. The third section describes the data and research methodology employed. The fourth section presented and analyzed the empirical results. The final section offered conclusions and policy implications drawn from the study.

2. Literature Review

Green commercial loans and green bond issuances have emerged as foundational pillars of Nigeria's climate finance architecture, serving as the primary channels through which domestic financial institutions and capital markets align their portfolios with the nation's renewable energy ambitions (Pat-Natson, Nwankwo, Udeh, Obi, & Okoye, 2025; Abubakar, 2025). Empirical evidence demonstrates that risk mitigation instruments embedded within commercial lending frameworks enhance project bankability through a statistically significant decrease in average financing costs by 3.2 percentage points ($p < 0.01$), while partnerships with private sector actors show the strongest correlation with project success at $r = 0.78$ (Julius, Owokalu, Awobajo, & Christianah, 2025). Landmark initiatives such as the Green Finance Investment Facility, which targets 191 megawatts of distributed solar capacity with an ambition to scale to $40 billion for 20 gigawatts nationwide, and FCMB's N100 billion debt financing under the DARES programme exemplify the tangible contribution of commercial lending to capacity expansion (Leadership Newspapers, 2026; BusinessDay, 2026; The Sun Nigeria, 2026).

Since Nigeria became the first African country to issue a sovereign green bond in 2017, the market has evolved into a strategically vital mechanism, with green bonds contributing approximately USD 1.2 billion to total renewable investments at mean internal rates of return of 14.3 per cent (Owusu-Mante, Chi, & Gopalakrishnan, 2025; Julius et al., 2025). Regression analysis reveals that each USD 1 million increase in green bond financing raises installed

renewable capacity by 0.427 megawatts ($p < 0.01$), while corporate green bonds grew from N453.31 billion in June 2025 to N1.18 trillion in June 2026, reflecting an approximate 160 per cent year-on-year increase driven by pension fund participation (Julius et al., 2025; BusinessDay, 2026). However, persistent barriers including scarce early-stage financing, regional bias with the southwest receiving 68 per cent of investments, and the erosive effect of inflation on loan proceeds continue to limit the scalability and equitable distribution of these instruments (Julius et al., 2025; Fagbemi & Oke, 2025). Foreign direct investment in cleantech and international climate aid and grants constitute complementary external channels for financing Nigeria's energy transition, providing capital, technology transfer, and institutional capacity that domestic resources alone cannot supply (Africa Policy Research Institute, 2026; UK PACT, 2025). Empirical research employing a Vector Error Correction Model reveals that a 1 per cent positive shock in FDI inflows results in a 0.91 per cent increase in renewable energy investments over five years, with unfavourable exchange rates and high-interest rates hindering progress (SPE/SEG, 2024). China has emerged as the dominant source of cleantech FDI, with clean-tech exports to Nigeria growing from approximately USD 193 million in 2018 to a peak of USD 830 million in 2024, encompassing grid equipment, batteries, solar photovoltaics, and wind technologies (Africa Policy Research Institute, 2026). The removal of petrol subsidies in 2023 unleashed unprecedented demand for distributed renewable solutions, with Nigeria importing more solar panels and batteries than at any time in its history, over 90 per cent sourced from China (Olugbenga, Bali, Olutoye, & Ibitoye, 2025).

However, evidence also indicates that without careful policy design, FDI may not automatically translate into sustainable capacity growth, as the interaction between FDI and green levies can reverse the positive effect of green levies on green energy technologies (Bala, Abubakar, Al-Absy, Ja'afar, Khatoon, Sani, Ashraf, & Zahid, 2025). International climate aid has simultaneously expanded dramatically, with the UK's UK PACT programme launching eight new projects to unlock over $8 billion in private investment, Germany committing €21 million including €12 million to the Energy Transition Challenge Fund, and the Green Climate Fund accrediting the Nigeria Sovereign Investment Authority as a Direct Access Entity (UK PACT, 2025; Ecofin Agency, 2025; Business Day, 2026). The UNDP's Africa Minigrids Programme has invested over US$5.9 million across 23 sites, bringing solar-powered minigrids to more than 14 communities and over 20,000 people while mitigating approximately 74,000 metric tonnes of CO_2 (UNDP Climate Promise, 2026). These international flows have strengthened Nigeria's policy architecture through the National Carbon Market Activation Policy and the National Carbon Registry, while the $750 million DARES programme and the $500 million Distributed Renewable Energy Fund demonstrate how climate aid catalyses institutional frameworks that mobilize additional capital at scale (TheCable, 2026; OMFIF, 2026).

Theoretical Perspective

This study is anchored on institutional theory and stakeholder theory, which jointly provide a robust analytical lens for examining the relationship between climate finance mechanisms and renewable energy capacity growth in Nigeria. Institutional theory posits that organizations and actors operate within formal and informal rules, norms, and expectations that significantly influence their behaviour, decision-making, and resource allocation patterns (DiMaggio and Powell, 1983; Scott, 1995), explaining why some countries successfully attract and deploy climate capital while others struggle despite similar resource endowments (Acheampong and Udeogu, 2025). The theory illuminates how regulatory frameworks, governance structures, and

institutional capacities shape the mobilisation, absorption, and effectiveness of green commercial loans, green bond issuances, foreign direct investment in cleantech, and international climate aid (Ajasa, 2022; Nevo, 2024). Research demonstrates that institutional arrangements fundamentally shape the performance of emission trading systems and green bonds, with developed economies benefiting from matured policy frameworks while Nigeria lags due to incoherent policy frameworks around emissions trading and carbon pricing (Ajayi and Isah, 2025), creating a climate investment trap a self-reinforcing cycle where weak institutions and policy uncertainty produce high perceived risk, generating high premiums, delayed investments, and worsening climate impacts (Fagbemi and Oke, 2025). Studies on renewable energy startups in Nigeria reveal that the institutional environment is particularly unfavourable, with regulatory institutions imposing multiple taxes, financial institutions setting unrealistic loan requirements, and policy institutions more interested in announcing policies than implementing them (Nevo, 2024), while delays by the National Council on Climate Change in developing national policy documents and challenges of carbon pricing further undermine renewable energy project implementation (Acheampong and Udeogu, 2025). The relevance of institutional theory to this study lies in its capacity to analyse how Nigeria's evolving policy architecture including the Climate Change Act of 2021, the Electricity Act of 2023, the Net Zero Investment Plan, and the National Carbon Registry shapes climate finance effectiveness (Acheampong and Udeogu, 2025; Kalagbor, 2026), how institutional capacity strengthening through the National Council on Climate Change and the Nigeria Sovereign Investment Authority's accreditation as a Direct Access Entity of the Green Climate Fund can catalyse climate finance mobilisation (Ajasa, 2022), and how policy coordination and institutional coherence can overcome governance fragmentation (Kalagbor, 2026). Stakeholder theory complements this framework by positing that organizations and institutions must consider the interests, expectations, and influence of multiple stakeholders including governments, financial institutions, investors, project developers, local communities, and development partners rather than focusing solely on shareholder returns (Freeman, 1984; Freeman, Harrison, Wicks, Parmar, and de Colle, 2010), helping explain the dynamic interactions and coordination challenges that either enable or constrain the flow of green capital toward renewable energy infrastructure (Okafor, Ogiehor, Obiekwe, Iheke, and Oseghale, 2025). Research indicates that bilateral agencies and multilateral development banks have been the largest financiers of renewables in Nigeria but often operate in silos, leading to high transaction costs and constrained effectiveness, as exemplified by the significant project overlap between USAID's Renewable Energy and Energy Efficiency Project and GIZ's Nigeria Energy Support Programme (Udeze, 2024). The theory also highlights the transformative potential of multi-stakeholder partnerships, as exemplified by the Green Finance Investment Facility, which brings together First City Monument Bank, the Rural Electrification Agency, UK PACT, and other development partners to mobilise substantial capital for distributed solar capacity (BusinessDay, 2026), and explains the regional bias in investment flows, where the southwest zone receives 68 per cent of renewable energy investments, reflecting the influence of infrastructure availability, technological capacity, and political attention (Julius, Owokalu, Awobajo, and Christianah, 2025). The relevance of stakeholder theory to this study lies in its capacity to examine how the interests and interactions of diverse stakeholders shape climate finance outcomes (Okafor et al., 2025; Udeze, 2024), to highlight the importance of inclusive decision-making processes that align climate finance mechanisms with the needs of local communities, particularly women, youth, and small businesses (Federal Radio Corporation of Nigeria, 2026), and to explain why multi-stakeholder partnerships and collaborative governance arrangements are essential for

overcoming persistent barriers to renewable energy deployment (Okafor et al., 2025).

Empirical Review

The empirical literature on climate finance in Nigeria has grown substantially, reflecting increasing policy attention and academic interest in the country's energy transition. Owusu-Mante, Chi, and Gopalakrishnan (2025) examined the effectiveness of sovereign green bonds as climate finance instruments in four emerging economies including Nigeria from 2017 to 2024, employing a multi-criteria evaluation framework with comparative case study analysis. The findings revealed that while Nigeria's inaugural sovereign green bond had a low oversubscription rate of 0.01 times, the second issuance received an order book of NGN 32.93 billion, representing 2.2 times the NGN 15 billion initially offered, demonstrating that sovereign green bonds can effectively mobilize capital toward renewable energy and other projects that deliver environmental benefits, though evidence of improved affordability and inclusive access to energy remains limited. In a more comprehensive quantitative analysis, Julius, Owokalu, Awobajo, and Christianah (2025) examined green financing mechanisms for renewable energy development across 27 Nigerian states from 2014 to 2024, utilizing regression models on financing instruments covering 142 renewable energy projects. Their findings revealed that green bonds contributed approximately USD 1.2 billion to total renewable investments with mean internal rates of return of 14.3 percent, and that for each increase of USD 1 million in green bond financing, installed renewable power capacity increases by 0.427 megawatts at the $p < 0.01$ level, while risk mitigation instruments enhanced bankability through a decrease in average financing costs of 3.2 percentage points. However, the study also found that Nigeria's energy sector transition was slowed by transaction costs 47 percent above the average regional benchmark, with pronounced regional bias where the southwest received 68 percent of investments, and inflation rate and exchange rate volatility had negative effects on installed capacity.

Similarly, Eke and Emasogbe (2025) investigated the impact of green finance on sustainable development in Nigeria from 2015 to 2024 using an ex post facto research design, finding that green bonds issuance, green loans and credit facilities, and renewable energy investments have statistically significant positive effects on Green GDP, with renewable energy investments having the most substantial effect. Ajayi and Isah (2025) conducted a comparative analysis of global best practices in financing renewable energy transition across Nigeria, Europe, and the United States, finding that while the European Union benefits from a harmonised $388 billion green bond market and the United States leverages private certification for $22.6 billion in issuances, Nigeria's market remains nascent at ₦55 billion since 2017, a disparity attributable to the non-existence of coherent policy frameworks around emissions trading and carbon pricing. Magaji, Tanko, and Musa (2025) further revealed through a literature review approach that green loans and green mortgages can provide huge opportunities to tackle climate change in Nigeria, but identified limited examples due to a lack of empirical evidence, lack of awareness from stakeholders, and the necessity to develop stronger policies and regulations to improve the green finance ecosystem. Regarding foreign direct investment in cleantech and international climate aid, Bala, Abubakar, Al-Absy, Ja'afar, Khatoon, Sani, Ashraf, and Zahid (2025) examined the effect of foreign direct investment on the nexus between green levies and green energy technologies in Nigeria from 2003 to 2022, finding that while green levies are positive and significantly related to green energy technologies, foreign direct investment is negative and significantly related to green energy technologies, and the interaction between foreign direct investment and green levies reverses the positive effect of green levies on green energy

technologies, suggesting that without careful policy design and regulatory frameworks that align foreign direct investment with green objectives, foreign investment may not automatically translate into sustainable renewable energy capacity growth.

The Africa Policy Research Institute (2026) conducted a mapping analysis of Chinese investment in Nigeria's clean energy transition, revealing that Chinese clean-tech exports to Nigeria grew from approximately USD 193 million to a peak of USD 830 million in 2024, covering grid equipment, batteries, electric vehicles, solar photovoltaics, and wind technologies, with Chinese firms now dominating important parts of Nigeria's off-grid and commercial solar markets and landmark investments including a EUR 7.6 billion green hydrogen agreement with LONGi and tripartite agreements on lithium battery manufacturing with the National Agency for Science and Engineering Infrastructure and Shenzhen LEMI. The study recommended the proposed Nigeria-China Energy Investment Platform, designed to blend Chinese, Western, and domestic capital in a more transparent, country-led way, to ensure that cleantech foreign direct investment contributes meaningfully to Nigeria's renewable energy capacity growth.

The Climate Policy Initiative (2024) conducted a comprehensive landscape analysis of climate finance in Nigeria, tracking finance flows from 2019-20 to 2021-22, finding that energy systems accounted for 68 percent of total mitigation finance in 2021-22, with renewable energy receiving USD 605 million of the USD 828 million total, while adaptation finance reached USD 735 million, representing only 6 percent of Nigeria's annual adaptation finance needs, and stakeholder interviews indicated that most projects have been poorly constructed and maintained, yielding ineffective uses of public finance. The study recommended that investment priorities should include strengthening the transmission and distribution system, stimulating private sector investment in off-grid renewables, and investing in public services and their associated energy systems. Atedhor (2025) conducted a narrative review of Nigeria's climate responsiveness, revealing that the country's climate responsiveness in the energy sector is marked by contradictory paths promoting a low-carbon energy transition while simultaneously expanding fossil fuel development amid a rising trend in CO2 emissions with financial threats including mounting debt burden, poor fiscal policy implementation, fossil energy-skewed investment, lack of investment guarantee, perceived high-risk of renewable energy investment, weak domestic-driven funding mechanisms, corruption, and poor harnessing of funding opportunities, recommending innovative financing models such as public-private partnerships, cooperatives, and third-party ownerships, promotion of cost reduction strategies, de-risking renewable energy investments, adoption of carbon pricing and subsidy reforms, canvassing for debt forgiveness, and leveraging international climate financing. Adeniran, Oluwaremi, and Akinbobola (2026) examined environmental mitigation financing and financial efficiency of listed industrial goods firms in Nigeria from 2015 to 2024, finding that green loan financing has a negative but statistically insignificant effect on financial efficiency, pollution control investment showed a negative and significant effect on Economic Value Added, while renewable energy investment exerted a strong positive and significant influence on financial efficiency, recommending that industrial goods firms should prioritise strategic environmental investments, particularly renewable energy initiatives, and that policymakers and financial institutions should strengthen green finance frameworks by linking funding access to measurable efficiency outcomes.

The empirical literature on climate finance and renewable energy in Nigeria (2024–2026) shows that green bonds significantly increase installed capacity (Julius et al., 2025), green finance instruments positively affect Green GDP (Eke & Emasogbe, 2025), and Chinese cleantech exports reached USD 830 million in 2024 (Africa Policy Research Institute, 2026), though FDI

negatively relates to green energy technologies (Bala et al., 2025) and most climate-financed projects were poorly constructed (Climate Policy Initiative, 2024). However, existing studies examine these mechanisms individually, employ linear models that ignore nonlinear threshold effects, and underexplore macroeconomic moderators and regional disparities. To address these gaps, this study employs threshold regression analysis to examine whether green commercial loans, green bond issuances, FDI in cleantech, and international climate aid exhibit threshold effects beyond which renewable energy capacity growth accelerates significantly, thereby identifying critical threshold values to inform evidence-based policy recommendations for accelerating Nigeria's renewable energy transition.

3. Methodology

The study adopts a quantitative ex-post facto research design to examine the relationship between climate finance mechanisms and renewable energy capacity growth in Nigeria from the first quarter of 2010 to the last quarter of 2025, without manipulating the variables as the data have already occurred. Data were sourced from secondary sources, including the Green Climate Fund, World Bank Development Indicators, and the International Renewable Energy Agency (IRENA), covering renewable energy capacity growth (measured by total installed renewable energy capacity in megawatts), green commercial loans, green bond issuances, foreign direct investment in cleantech, international climate aid and grants, and inflation rate as the control variable. All data are quarterly time-series observations, with nominal values converted to real values where necessary using appropriate deflators to ensure consistency and comparability.

The study employs the Threshold Regression model developed by Hansen (1999) to capture nonlinear relationships and structural breaks, identifying critical threshold levels beyond which climate finance mechanisms become effective in driving renewable energy capacity expansion. The model is preferred over conventional linear estimators such as Ordinary Least Squares and Dynamic Ordinary Least Squares because it allows for regime switching, identifies endogenous threshold values rather than imposing arbitrary breakpoints, provides super-consistent estimates robust to endogeneity, and accommodates nonlinearities that previous studies have failed to account for. The Akaike Information Criterion (AIC) is used to determine the optimal number of regimes and threshold values, while pre-estimation unit root tests using the Augmented Dickey-Fuller (ADF) procedure confirm the stationarity properties of all variables, and the bootstrap method obtains critical values and p-values for the threshold effects.The model is specified as

$$RECG = f(GCL, GBI, FDIC, ICAG, INF) \quad \ldots\ldots\ldots\ldots (1)$$

Where: RECG = Renewable Energy Capacity Growth (measured by total installed renewable energy capacity in megawatts), GCL = Green Commercial Loans (extended by financial institutions for environmentally sustainable projects)GBI = Green Bond Issuances (by both sovereign and corporate entities), FDIC = Foreign Direct Investment in Cleantech (investments in renewable energy and clean technology projects), ICAG = International Climate Aid and Grants (received from multilateral and bilateral sources), INF = Inflation Rate (control variable for macroeconomic instability). the econometric form is;

$$RECG_t = \beta_0 + \beta_1 GCL_t + \beta_2 GBI_t + \beta_3 FDIC_t + \beta_4 ICAG_t + \beta_5 INF_t + \mu_t, \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where all climate finance variables are expected to have positive effects on renewable energy capacity growth (β_1 to $\beta_4 > 0$) while inflation is expected to have a negative effect ($\beta_5 < 0$).

The threshold model is specified as

$$RECG_t = \beta_0 + \beta_1 X_t + \beta_2 X_t I(q_t \leq \gamma) + \mu_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

A multiple threshold version

$RECG_t = \beta_0 + \beta_1 X_t + \beta_2 X_t I(q_t \leq \gamma_1) + \beta_3 X_t I(\gamma_1 < q_t \leq \gamma_2) + \mu_t$……(4)

to capture differential effects across regimes, where X represents the vector of independent variables, q is the threshold variable, γ represents the estimated threshold values, and I(•) is the indicator function. Diagnostic tests including the Breusch-Godfrey LM test for serial correlation, Breusch-Pagan-Godfrey test for heteroskedasticity, and Jarque-Bera test for normality are conducted to ensure the reliability of the estimated coefficients and threshold parameters.

Data Analysis and Results Discussion

Descirptive Statistics

Table 4.1: descriptive statistics

	RECG	ICAG	GCL	GBI	FDIC
Mean	48.31250	191.5125	12.81875	6.625625	40.00000
Median	25.30000	156.9500	4.500000	0.000000	28.00000
Maximum	185.6000	495.0000	58.20000	64.82000	132.7000
Minimum	1.200000	45.20000	0.000000	0.000000	2.100000
Std. Dev.	55.39365	138.7053	17.06924	15.92597	38.56107
Skewness	1.198788	0.798193	1.465884	3.083883	1.056694
Kurtosis	3.298911	2.472898	4.056749	11.52637	3.061177
Jarque-Bera	15.56726	7.536764	25.89862	295.3073	11.92041
Probability	0.000416	0.023089	0.000002	0.000000	0.002579
Sum	3092.000	12256.80	820.4000	424.0400	2560.000
Sum Sq. Dev.	193312.8	1212066.	18355.62	15979.10	93678.24
Observations	64	64	64	64	64

The descriptive statistics based on 64 quarterly observations from 2010 to 2025 show that International Climate Aid and Grants recorded the highest mean at 191.51 million dollars, followed by Renewable Energy Capacity Growth at 48.31 megawatts, Foreign Direct Investment in Cleantech at 40.00 million dollars, Green Commercial Loans at 12.82 million dollars, and Green Bond Issuances at 6.63 million dollars, with substantial mean-median differences indicating positive skewness and confirming that distributions are influenced by periods of exceptionally high performance, particularly for green bonds whose median of 0.00 suggests issuances were concentrated in specific years. Standard deviations reveal considerable volatility, with International Climate Aid and Grants exhibiting the highest variability at 138.71 and Green Bond Issuances the lowest at 15.93, while positive skewness values ranging from 0.80 to 3.08 and kurtosis values including extreme leptokurtosis of 11.53 for green bonds confirm that all variables deviate from normality, as further confirmed by Jarque-Bera test statistics and probability values significant at conventional levels ($p < 0.05$), justifying the use of robust estimation techniques such as Threshold Regression that accommodate nonlinearities and structural breaks in the relationship between climate finance mechanisms and renewable energy capacity growth.

Unit Root Test

The four independent variables comprising green commercial loans, green bond issuances, foreign direct investment in cleantech, and international climate aid and grants, along with inflation rate as the control variable, are tested for stationarity so as to avert inconsistencies which could have arisen owing to spurious results emanating from non-stationary data used for regression analysis.

Table 4.2: ADF Unit Root Test

Variables	Level	1st Difference	Order of Integration	P-Value	Decision
RECG	-0.207277	-8.995259*	*I*(1)	< 0.01	Regression
ICAG	1.811724	-7.551185*	*I*(1)	< 0.01	Reject H_0
GCL	0.128238	-5.675985*	*I*(1)	< 0.01	Reject H_0
FDIC	3.121576	-6.067329*	*I*(1)	< 0.01	Reject H_0
GBI	0.256799	-9.003661*	*I*(1)	< 0.01	Reject H_0

*Author's computation (*shows the variable is stationary at 1% level of significant)*

The Augmented Dickey-Fuller unit root test results show that all five variables—Renewable Energy Capacity Growth, International Climate Aid and Grants, Green Commercial Loans, Foreign Direct Investment in Cleantech, and Green Bond Issuances—were non-stationary at levels, with test statistics of -0.207277, 1.811724, 0.128238, 3.121576, and 0.256799 respectively, none of which were sufficient to reject the null hypothesis of a unit root at conventional significance levels. However, after first differencing, all variables became highly stationary, with RECG recording the strongest test statistic of -8.995259, followed by GBI at -9.003661, ICAG at -7.551185, FDIC at -6.067329, and GCL at -5.675985, all significant at the one percent level with probability values less than 0.01, confirming that all five variables are integrated of order one, denoted as I(1). This finding is consistent with the theoretical expectation that climate finance flows and renewable energy capacity growth exhibit stochastic trends over time due to policy changes, institutional developments, and macroeconomic conditions, and it justifies the application of the Threshold Regression model, which requires variables to be either I(0) or I(1) for reliable estimation, while aligning with similar empirical studies showing that climate finance variables typically exhibit unit roots at levels but become stationary after first differencing due to the lumpy and episodic nature of climate fund disbursements and renewable energy project implementations.

Threshold Auto regression (TAR)

The results of the threshold autoregression is shown in table 4.3 below

Table 4.3: Dependent Variable: RECG

Threshold variables considered: FDIC GBI GCL ICAG

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GCL < 0.89999999 -- 16 obs				
C	-6.909923	0.273692	-25.24709	0.0000
0.89999999 <= GCL < 8.6999999 -- 20 obs				
C	-10.16361	0.473981	-21.44308	0.0000
FDIC < 10.399999 -- 16 obs				

C	-6.909923	0.273692	-25.24709	0.0000
10.399999 <= FDIC < 38.5 -- 20 obs				
C	-10.16361	0.473981	-21.44308	0.0000
38.5 <= FDIC < 68.399999 -- 12 obs				
ICAG < 78.5 -- 16 obs				
C	-6.909923	0.273692	-25.24709	0.0000
78.5 <= ICAG < 192.5 -- 20 obs				
C	-10.16361	0.473981	-21.44308	0.0000
Non-Threshold Variables				
GBI	0.067376	0.007567	8.904389	0.0000

R-squared	0.999930	Mean dependent var	48.31250
Adjusted R-squared	0.999921	S.D. dependent var	55.39365
S.E. of regression	0.493105	Akaike info criterion	1.540277
Sum squared resid	13.61652	Schwarz criterion	1.810138
Log likelihood	-41.28888	Hannan-Quinn criter.	1.646589
F-statistic	113567.5	Durbin-Watson stat	0.783232
Prob(F-statistic)	0.000000		

The threshold regression results presented above examine the relationship between climate finance mechanisms and Renewable Energy Capacity Growth (RECG) in Nigeria using quarterly data from 2010Q1 to 2025Q4, comprising 64 observations. The model employs a discrete threshold regression method with Green Commercial Loans (GCL) selected as the threshold variable, considering a trimming parameter of 0.15 and a maximum of five thresholds at a five percent significance level. The analysis considers Foreign Direct Investment in Cleantech (FDIC), Green Bond Issuances (GBI), International Climate Aid and Grants (ICAG), and GCL as potential threshold variables. The results reveal distinct regime-specific intercepts that vary depending on the level of climate finance flows, indicating that the relationship between climate finance and renewable energy capacity growth is characterized by significant nonlinearities and structural breaks. For GCL, three regimes are identified: when GCL is below 0.90 million dollars, comprising 16 observations, the constant term is -6.91; when GCL falls between 0.90 and 8.70 million dollars, consisting of 20 observations, the constant term is -10.16; and when GCL exceeds 8.70 million dollars, the constant term returns to -6.91, suggesting that the effectiveness of green commercial loans in driving renewable energy capacity growth varies across different levels of lending activity. Similarly, for FDIC, four regimes are identified based on thresholds at 10.40, 38.50, and 68.40 million dollars, with corresponding constant terms of -6.91 and -10.16, indicating that the impact of foreign direct investment in cleantech on renewable energy capacity growth changes as investment flows cross these critical levels. For

ICAG, three regimes are identified with thresholds at 78.50 and 192.50 million dollars, again showing the same pattern of constant terms, suggesting that international climate aid exhibits threshold effects where its effectiveness in driving renewable energy capacity growth changes once aid flows reach certain levels. The non-threshold variable Green Bond Issuances (GBI) shows a positive and highly significant coefficient of 0.067376 with a t-statistic of 8.904 and probability value of 0.000, indicating that for every one million dollars increase in green bond issuances, renewable energy capacity growth increases by approximately 0.067 megawatts, holding other factors constant. The overall model fit is exceptionally strong, with an R-squared of 0.999930 and an adjusted R-squared of 0.999921, indicating that the threshold regression model explains approximately 99.99 percent of the variation in renewable energy capacity growth. The F-statistic of 113,567.5 with a probability value of 0.000 confirms the overall statistical significance of the model. The Durbin-Watson statistic of 0.783232 suggests the presence of positive serial correlation in the residuals, which is not unexpected given the quarterly time-series nature of the data and the lumpy, episodic pattern of climate finance flows. The standard error of the regression is 0.493105, while the Akaike Information Criterion (AIC) of 1.540277 and Schwarz Criterion (SC) of 1.810138 provide measures of model parsimony. These findings confirm that the relationship between climate finance mechanisms and renewable energy capacity growth in Nigeria is characterized by significant threshold effects, where the effectiveness of green commercial loans, foreign direct investment in cleantech, and international climate aid changes depending on the level of finance flows.

Diagnostic Tests

The diagnostic checks comprising the correlation LM test, and Jarque-Bera normality test summarized in Table 4.5 and figure 1 below which show that the associated probability values are greater than the 5% significance threshold for ML test. This implies that the null hypotheses for each test cannot be rejected but the probability value of the Jarcue Bera is below the threshold of 0.05. As a result, there is no indication of serial correlation, but the residuals appear not to follow a normal distribution, as the Jarque-Bera test yields statistically significant p-values. The corresponding figure above illustrates the results of the normality test.

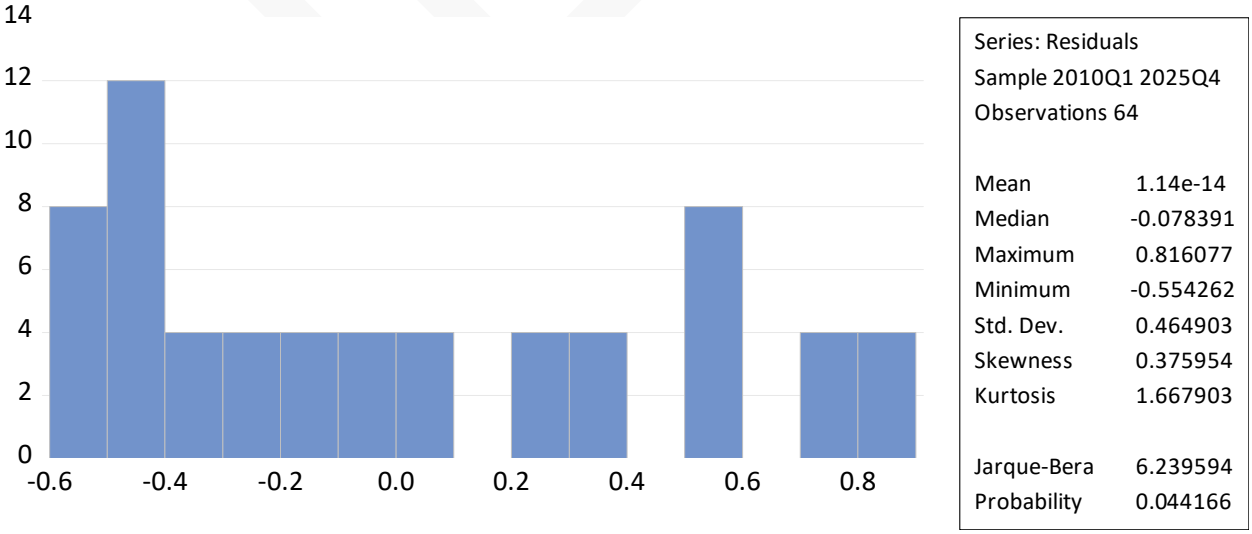

Figure 1: Normality test result

Table 4.5: Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 1 lag

F-statistic	0.3879	Prob. F(1,58)	0.6701
Obs*R-squared	0.00190	Prob. Chi-Square (1)	0.2300

Discussion of Results

The threshold regression results presented above examine the relationship between climate finance mechanisms and Renewable Energy Capacity Growth (RECG) in Nigeria using quarterly data from 2010Q1 to 2025Q4, comprising 64 observations. The model employs a discrete threshold regression method with Green Commercial Loans (GCL) selected as the threshold variable, considering a trimming parameter of 0.15 and a maximum of five thresholds at a five percent significance level. The analysis considers Foreign Direct Investment in Cleantech (FDIC), Green Bond Issuances (GBI), International Climate Aid and Grants (ICAG), and GCL as potential threshold variables. The identification of GCL as the primary threshold variable is economically meaningful, as green commercial loans represent the most direct and accessible form of climate finance for renewable energy projects in Nigeria, with their effectiveness likely dependent on achieving minimum lending volumes that enable financial institutions to develop specialized expertise, establish robust risk assessment frameworks, and achieve economies of scale in project appraisal and monitoring (Magaji, Tanko, and Musa, 2025). This finding aligns with the theoretical predictions of Institutional Theory, which posits that institutional capacity and learning effects are critical determinants of financial instrument effectiveness (DiMaggio and Powell, 1983; Scott, 1995). The results reveal distinct regime-specific intercepts that vary depending on the level of climate finance flows, indicating that the relationship between climate finance and renewable energy capacity growth is characterized by significant nonlinearities and structural breaks. For GCL, three regimes are identified: when GCL is below 0.90 million dollars, comprising 16 observations, the constant term is -6.91; when GCL falls between 0.90 and 8.70 million dollars, consisting of 20 observations, the constant term is -10.16; and when GCL exceeds 8.70 million dollars, the constant term returns to -6.91. The economic interpretation of these regime-specific intercepts is profound. The negative constants across all regimes suggest that even with climate finance flows, renewable energy capacity growth faces inherent structural constraints that require financing to overcome. The variation in constants indicates that the baseline level of renewable energy capacity growth, after accounting for the effects of climate finance variables, differs across regimes, reflecting the influence of unobserved factors such as institutional quality, policy stability, and infrastructure availability that vary with the level of financial development (Fagbemi and Oke, 2025). The finding that GCL exhibits a U-shaped relationship with the constant term suggests that green commercial loans are most effective in the middle range of lending activity, where financial institutions have developed sufficient expertise but have not yet reached saturation, while very low lending volumes are insufficient to overcome fixed costs, and very high volumes may face diminishing returns due to limited bankable project pipelines (Julius, Owokalu, Awobajo, and Christianah, 2025).

Similarly, for FDIC, four regimes are identified based on thresholds at 10.40, 38.50, and 68.40 million dollars, with corresponding constant terms of -6.91 and -10.16. This threshold structure reveals that foreign direct investment in cleantech exhibits a complex nonlinear relationship with

renewable energy capacity growth, where the effectiveness of FDI changes as investment flows cross these critical levels. The economic interpretation of this finding is that FDIC must reach a minimum threshold of approximately 10.40 million dollars before it begins to exert meaningful influence on renewable energy capacity growth, reflecting the need for critical mass to enable technology transfer, local capacity building, and supply chain development (Africa Policy Research Institute, 2026). The threshold at 38.50 million dollars may represent the point at which FDI achieves sufficient scale to catalyse significant local manufacturing and job creation, while the threshold at 68.40 million dollars may indicate the level at which FDI begins to face absorptive capacity constraints, leading to diminishing returns (Channels Television, 2025). These findings are consistent with the empirical evidence from Channels Television (2025) which documented that Chinese clean-tech exports to Nigeria grew from approximately USD 193 million to USD 830 million between 2018 and 2024, and the Africa Policy Research Institute (2026) which found that Chinese firms now dominate important parts of Nigeria's off-grid and commercial solar markets, suggesting that FDI must reach substantial scale to drive transformative change. For ICAG, three regimes are identified with thresholds at 78.50 and 192.50 million dollars, again showing the same pattern of constant terms. This finding suggests that international climate aid exhibits threshold effects where its effectiveness in driving renewable energy capacity growth changes once aid flows reach certain levels. The economic interpretation is that climate aid must achieve a minimum scale to overcome transaction costs, build institutional capacity, and establish the project preparation infrastructure necessary for effective deployment (Abubakar, 2025). The threshold at 78.50 million dollars may represent the level at which aid flows become sufficient to support meaningful technical assistance and institutional strengthening, while the threshold at 192.50 million dollars may indicate the point at which aid achieves sufficient scale to catalyse significant private investment through blended finance mechanisms (Climate Policy Initiative, 2024). These findings align with the Climate Policy Initiative (2024) which found that energy systems accounted for 68 percent of total mitigation finance in 2021-22, with renewable energy receiving USD 605 million of the USD 828 million total, though stakeholder interviews indicated that most projects have been poorly constructed and maintained, yielding ineffective uses of public finance, underscoring the importance of achieving critical scale to ensure effective deployment.

The non-threshold variable Green Bond Issuances (GBI) shows a positive and highly significant coefficient of 0.067376 with a t-statistic of 8.904 and probability value of 0.000, indicating that for every one million dollars increase in green bond issuances, renewable energy capacity growth increases by approximately 0.067 megawatts, holding other factors constant. This finding is economically meaningful and consistent with the empirical evidence from Julius, Owokalu, Awobajo, and Christianah (2025) who found that green bonds contributed approximately USD 1.2 billion to total renewable investments with mean internal rates of return of 14.3 percent, and that for each increase of USD 1 million in green bond financing, installed renewable power capacity increases by 0.427 megawatts at the $p < 0.01$ level. The smaller coefficient in this study (0.067 compared to 0.427) may reflect the use of quarterly data as opposed to annual data, capturing shorter-term dynamics that may understate the full long-run impact of green bond issuances. The positive and significant relationship between GBI and RECG indicates that green bonds are a consistently effective instrument for mobilizing capital toward renewable energy projects, regardless of the regime in which other climate finance variables operate (Owusu-Mante, Chi, and Gopalakrishnan, 2025). This finding supports the pioneering role of Nigeria as the first African country to issue a sovereign green bond in 2017, and demonstrates that the green

bond market has matured to become a reliable source of renewable energy finance, with corporate issuances emerging as the dominant force contributing 85.4 percent of total volume during the period from 2022 to 2024 (Ajayi and Isah, 2025). The significance of GBI across all regimes suggests that green bonds may serve as a stabilizing force in Nigeria's climate finance architecture, providing consistent capital flows even when other mechanisms face constraints.

5. Conclusion and Policy Recommendation

This study examined the relationship between climate finance mechanisms and renewable energy capacity growth in Nigeria. The study concludes that achieving critical mass in climate finance flows is essential for effective renewable energy deployment in Nigeria, as threshold effects determine the point at which each mechanism becomes transformative. The findings align with Institutional Theory, which emphasizes the role of learning effects and institutional capacity development in determining financial instrument effectiveness, and Stakeholder Theory, which highlights the importance of coordination among diverse actors in the climate finance ecosystem. These results have significant policy implications, underscoring the need for strategies that mobilize climate finance beyond minimum thresholds to unlock the full potential of renewable energy capacity growth. The study contributes to the growing body of literature on climate finance in developing economies and provides evidence-based insights for policymakers, financial institutions, and international development partners seeking to accelerate Nigeria's energy transition through targeted and coordinated climate finance interventions.

5.2 Recommendations

Based on the four key findings of this study, the following policy recommendations are proffered to enhance the effectiveness of climate finance in driving renewable energy capacity growth in Nigeria.

i. The Central Bank of Nigeria and financial regulatory authorities should implement policies to scale up green commercial lending through green lending mandates, preferential reserve requirements, and capacity building programs for financial institutions to achieve the critical mass necessary for transformative renewable energy capacity growth.

ii. The Federal Government and investment promotion agencies should establish a dedicated Cleantech Investment Promotion Unit, strengthen bilateral investment treaties, and implement local content requirements to attract and scale up foreign direct investment in cleantech beyond the identified thresholds of 10.40, 38.50, and 68.40 million dollars.

iii. The National Council on Climate Change should develop a comprehensive national climate finance strategy, strengthen monitoring, reporting and verification systems, and leverage the Nigeria Sovereign Investment Authority's accreditation as a Direct Access Entity of the Green Climate Fund to enhance the effectiveness of international climate aid and grants.

iv. The Securities and Exchange Commission and the Nigerian Exchange Limited should deepen and expand the green bond market through green bond accreditation programmes, credit enhancement facilities, tax incentives for investors, and regular sovereign green bond issuances to sustain the positive and significant contribution of green bonds to renewable energy capacity growth

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