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Impact Of Green Bonds, Green Loans And Green Risk Insurance On Nigeria's Economic Growth Using An ARDL Bounds Testing Approach

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Abstract
This study evaluates the contributions of green bonds, green loans and green risk insurance to economic growth in Nigeria over the period 2005–2022. Building on the environmental finance literature, we employ the autoregressive distributed lag (ARDL) bounds testing procedure to capture both short-run dynamics and long-run equilibrium relationships among the selected green finance instruments and real gross domestic product. Diagnostic tests confirm the absence of serial correlation, heteroskedasticity and functional misspecification, while stability of the estimated coefficients is established via cumulative sum (CUSUM) tests. Empirical findings reveal that in the long run, green bond issuance and green loan disbursements exert a positive and statistically significant effect on GDP growth, with elasticities of 0.23 and 0.17, respectively. Green risk insurance contributions also display a positive long-run association, albeit at a lower magnitude (elasticity of 0.09). In the short run, adjustments toward equilibrium occur at a speed of 42 percent per annum, and green bonds immediately stimulate growth, whereas green loans and insurance manifest more gradual effects. Policy simulations underscore that a 10 percent increase in green bond volumes can accelerate GDP growth by approximately 2.3 percent over a five-year horizon. The study concludes that strengthening Nigeria's green finance architecture—through regulatory incentives for bond market development, enhanced credit guarantees for environmentally sustainable projects and the expansion of risk insurance schemes—can foster a more resilient and inclusive growth trajectory. Implications for policymakers and financial regulators center on the design of tailored fiscal and monetary instruments to mobilize private capital toward a low-carbon transition.

Key words: *Green Financing, Green Bonds Issued, Green Loan Financing, Green Risk Insurance, Bounds Test.*

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I. Introduction

In recent decades, the growing urgency of climate change and environmental degradation has necessitated a shift in global financial priorities. As nations seek to transition toward more sustainable development models, green finance has emerged as a pivotal mechanism for achieving both environmental and economic objectives. Green finance encompasses a wide array of financial instruments, investments, and policies that promote environmentally sustainable development. These include green bonds, climate risk insurance, renewable energy investments, and eco-friendly banking practices.

In the context of Nigeria, Africa's most populous country and largest economy, the relevance of green finance is both timely and critical. Nigeria faces mounting environmental challenges, including desertification, deforestation, air and water pollution, and the increasing impact of climate-related disasters. These environmental threats pose significant risks to livelihoods, agricultural productivity, and infrastructure—ultimately hampering economic growth and development.

Despite its vast natural and human resources, Nigeria's economic growth has remained largely dependent on oil and gas exports. This dependence has not only made the economy vulnerable to global oil price fluctuations but has also contributed significantly to environmental degradation and greenhouse gas emissions. As the global economy gradually shifts towards low-carbon pathways, Nigeria must adapt by diversifying its economy and integrating green financial mechanisms.

Green finance offers Nigeria an opportunity to realign its growth trajectory with global sustainability goals. Through investments in renewable energy, sustainable agriculture, waste management, and green

infrastructure, Nigeria can stimulate job creation, attract foreign direct investment (FDI), and reduce poverty—all while preserving its natural environment. However, the country faces significant hurdles in scaling green finance, including weak institutional frameworks, limited financial literacy, and a lack of investor confidence.

Internationally, green finance has been a driving force behind economic transitions in emerging markets such as China, India, and South Africa. These countries have implemented targeted policies and incentive structures to attract green investments and finance sustainable infrastructure projects. Nigeria, by learning from these examples, can formulate its own green finance strategy tailored to its unique socio-economic and environmental context.

As the environmental risks associated with traditional economic practices became more evident, the need for financial solutions that could support sustainable development became clear. Green finance solutions were seen as a way to channel capital into projects and initiatives that would help address these challenges.

The Nigerian government has taken preliminary steps to integrate green finance into national planning. This includes the launch of green bond programs to finance renewable energy and afforestation projects, as well as the formulation of a Nationally Determined Contribution (NDC) roadmap in alignment with the Paris Agreement. These initiatives signal a growing recognition of the importance of sustainable finance in achieving long-term development goals.

However, the practical implementation of green finance in Nigeria remains limited and fragmented. There is a need for a more coordinated approach involving public institutions, the private sector, financial institutions, and civil society. The banking sector, in particular, plays a critical role in channeling capital toward green projects but often lacks the regulatory incentives and risk assessment tools needed to prioritize environmental sustainability.

Despite the challenges, Nigeria holds significant potential to become a leader in green finance in West Africa. The country's youthful population, growing financial technological sector, and abundant renewable energy resources—especially solar—offer a foundation for sustainable economic transformation. With the right policy support and institutional capacity building, green finance can become a catalyst for inclusive and resilient growth.

This study is also important in light of Nigeria's commitment to the United Nations Sustainable Development Goals (SDGs), particularly those related to climate action, affordable and clean energy, and decent work and economic growth. Green finance provides a practical mechanism through which these interconnected goals can be pursued simultaneously.

Despite the increasing global momentum toward economic growth and climate-conscious financing, Nigeria's economic growth remains heavily reliant on fossil fuels and environmentally damaging practices. While the country has made some progress through initiatives like green bonds and commitments to international climate agreements, the integration of green finance into the broader economic framework is still limited. The financial sector lacks adequate incentives, regulatory frameworks, and technical capacity to mainstream green investments. This gap not only slows down environmental sustainability efforts but also restricts the potential for long-term, economic growth that is resilient to climate risks.

Furthermore, there is limited empirical research exploring the direct and indirect impacts of green finance on Nigeria's economic performance. Key questions remain unanswered: To what extent does green finance contribute to GDP growth? Which sectors are most responsive to green financial interventions, and what barriers hinder the effective flow of green finance? Without a deeper understanding of these dynamics, policymakers may continue to implement fragmented or ineffective strategies, missing a critical opportunity to leverage green finance as a tool for economic transformation. This study aims to fill that gap by investigating the impact of green finance on economic growth in Nigeria.

II. Literature Review

Conceptual Review

Green Finance

Green finance refers to financial services and investments that support projects and initiatives with positive environmental outcomes, aiming to mitigate the impacts of climate change, promote sustainable development, and protect natural resources (Adewumi, Ibeh, Asuzu, Adelekan, Awonnuga, and Daraojimba, 2024), (Iwuanyanwu, Gil-Ozoudeh, Okwandu and Ike 2024). In the context of growing environmental challenges, green finance plays a pivotal role in channeling capital towards initiatives that reduce carbon emissions, support the transition to renewable energy sources, and enhance resilience to climate-related risks.

Green finance encompasses a range of financial instruments, including green bonds, green loans, and impact investing, designed to fund projects that contribute to environmental protection, renewable energy, and resource efficiency. Key developments in green finance include the growth of green bond markets, which have seen significant expansion globally. These bonds offer a way for governments, corporations, and financial institutions to raise funds for environmentally friendly projects.

Green finance is an emerging field within the financial industry that aims to facilitate investments and financial flows to projects, activities, and initiatives with positive environmental impacts. It plays a crucial role in addressing the urgent challenges posed by climate change, biodiversity loss, and the transition to a sustainable, low-carbon economy. At its core, green finance seeks to promote economic growth while ensuring that environmental sustainability remains a priority (Agu, Abhulimen, Obiki-Osafiele, Osundare, Adeniran, and Efunniyi, 2024).

Green finance is a concept born under the premise of the continuous development of industrialization in various countries around the world, and is closely integrated with the essence of finance and financial theory. It is also called "environmental finance" or "sustainable finance". Green finance originated in 1998. The green financial system acts as a channel for capital and resource regulation for green growth through tools such as green credit and investment, and government budget for the environment (Kun, Yu, Fu, Wang and Wang 2022).

Green finance promotes the development and utilization of new energy sources, green production, and ecological agriculture for the sustainable development of the whole society through prioritizing credit granting to businesses in the agricultural sector, limiting new projects that cause pollution and applying high interest rates (Bhatnagar 2022). Green finance is a core part of the low carbon green growth, because it connects the financial industry, environmental improvement and economic growth.

Green finance operates on several core principles that guide the allocation of capital to sustainable projects. These principles emphasize transparency, accountability, and the clear identification of environmental benefits. Investors, financial institutions, and governments all play a pivotal role in ensuring that the projects funded under green finance initiatives align with recognized environmental standards and objectives (Abdul-Azeez, Nwabekee, Agu, and Ignatius, 2024). Green finance plays a critical role in financing the development of renewable energy infrastructure, including the construction of power plants, installation of energy storage systems, and the expansion of grid networks to accommodate clean energy (Akinsulire, Idemudia, Okwandu, and Iwuanyanwu, 2024; Folorunso, Mohammed, Wada, and Samuel, 2024; Mokogwu, Achumie, Gbolahan, Adeleke, and Ewim 2024). By providing the necessary capital, green finance supports the growth of renewable energy markets and helps accelerate the transition to a low-carbon energy system.

Green finance facilitates investments in energy-efficient buildings, industrial processes, and transportation systems, helping to reduce overall energy demand and carbon emissions (Aniebonam, 2024). Green finance helps promote the adoption of sustainable farming practices, such as precision agriculture, organic farming, and agroforestry, which aim to reduce environmental impact while ensuring food security and supporting rural livelihoods. By financing projects that improve agricultural productivity while protecting natural resources, green finance contributes to the long-term sustainability of the agricultural sector.

Other sectors targeted by green finance include sustainable transportation, waste management, water conservation, and green infrastructure development. In each of these areas, green finance supports the transition to more sustainable practices and technologies, helping to reduce environmental impact and improve resource management (Agu, Abhulimen, Obiki-Osafiele, Osundare, Adeniran, and Efunniyi 2024). For example, investments in electric vehicle infrastructure, waste recycling technologies, and water-efficient systems all contribute to sustainability goals and are increasingly financed through green finance mechanisms. Operationally, green finance involves mobilizing public and private sector resources to fund projects that help reduce carbon emissions, enhance energy efficiency, and support the transition to a low-carbon, sustainable economy. It involves the financing of investments that provide environmental benefits in the broader context of environmentally sustainable development such as renewable energy, pollution prevention, and biodiversity conservation. Green finance in the Nigerian context refers to financial flows—both public and private—that support sustainable economic activities and projects, particularly those that help reduce environmental risks and promote climate- related development.

Green Bond

One of the primary types of green finance instruments is green bonds, which are debt instruments issued by governments, corporations, or other entities to raise capital for environmentally beneficial projects. The proceeds from green bonds are typically earmarked for projects related to renewable energy, energy efficiency, clean transportation, or sustainable infrastructure (Attah, Garba, Gil-Ozoudeh, and Iwuanyanwu, 2024). These bonds are designed to attract investors who are interested in supporting sustainability initiatives while earning a return on their investment. Green bonds have gained significant popularity in recent years as both institutional and retail investors seek opportunities to align their portfolios with environmental objectives.

Green bonds are debt instruments issued by governments, corporations, or other entities to raise capital specifically for environmental projects. The issuance of green bonds has provided a way for both public and private sector entities to raise funds for projects that address climate change, promote renewable energy, and support environmental sustainability. Key players in the green bond market include governments, development banks, corporations, and financial institutions that have committed to integrating environmental considerations

into their investment strategies. Governments and multilateral organizations have been instrumental in establishing the regulatory frameworks and guidelines that govern the green bond market, ensuring that proceeds are used for environmentally beneficial projects (Nwabekee, Abdul-Azeez, Agu and Ijomah 2024).

Green Loan

Green loans are another important instrument within the green finance ecosystem. Green loans provide capital for projects with environmental benefits. However, green loans are typically more flexible than bonds and are often used for specific projects or investments by businesses or corporations. These loans are generally structured to incentivize borrowers to meet certain environmental criteria, such as reducing carbon emissions or adopting sustainable business practices (Adetumi, Somto, Ngodoo, and Ajani, 2024; Garba, Umar, Umana, Olu, and Ologun, 2024; Manuel, Kehinde, Agupugo and Manuel, 2024). Green loans can be particularly useful for companies seeking to finance specific green initiatives, such as upgrading energy-efficient systems or developing renewable energy infrastructure. By offering favorable terms and conditions for green projects, green loans are designed to promote environmentally responsible investments across industries.

Green loans are often structured with favorable terms to incentivize borrowers to meet specific environmental goals, such as reducing carbon emissions or improving energy efficiency. Green loans are particularly useful for companies that are not able to access the capital markets or prefer not to issue bonds. Green loans are also being used by governments and public sector entities to fund green infrastructure projects, such as public transportation systems, water conservation initiatives, and sustainable urban development.

To Kazemzadeh, Fuinhas, Koengkan, Osmani and Silva (2022), green loan is a type of financing instrument where the proceeds are exclusively used to fund or refinance projects that have clear environmental benefits, in alignment with internationally recognized standards. Green loans are credit products offered by financial institutions to support environmentally sustainable projects such as renewable energy, energy efficiency, sustainable waste management, and green buildings, with loan terms often including incentives such as lower interest rates or longer repayment periods based on environmental performance.

A green loan is a financial tool that enables borrowers to invest in projects that reduce carbon emissions, preserve natural resources, and promote ecological resilience, thereby contributing to broader climate goals and sustainable development within the green finance ecosystem.

Green Risk Insurance

Green risk insurance is a financial mechanism that provides coverage against environmental risks, such as pollution, climate change impacts, or ecosystem degradation, helping protect green projects and sustainable assets from potential losses. It is designed to mitigate the financial impact of climate-related events—such as floods, droughts, and storms—on green infrastructure and environmentally responsible investments, supporting long-term climate resilience (Wu, Li, Hao, Ren and Zhang 2020).

In green finance, green risk insurance refers to specialized insurance products that underwrite the unique risks associated with sustainable and low-carbon investments, encouraging capital flow into green sectors by reducing investor uncertainty. Green risk insurance is a tool promoted within sustainable finance frameworks to manage liabilities and enhance risk-sharing for environmental compliance, natural disaster response, and green project implementation (Meo, and AbdulKarim, 2022).

According to Sun, Liu and Qayyum (2021), green risk insurance facilitates the transition to a green economy by enabling coverage for emerging technologies and innovations (e.g., carbon capture, clean hydrogen), which may face untested environmental and operational risks. From a sustainable development lens, green risk insurance safeguards the social and environmental returns of green investments by managing risks that could undermine community resilience or ecological balance.

Green risk insurance supports the development of green projects—such as renewable energy plants or sustainable agriculture—by protecting investors and developers against environmental risks that may disrupt operations or profitability.

Theories of Green Finance

Three major theories underpin green finance, each offering a different perspective on how financial systems can support environmental sustainability. These are:

Stakeholder Theory

Stakeholder theory argues that businesses and financial institutions should consider the interests of all stakeholders—not just shareholders—when making decisions. In green finance, this means factoring in the environmental and social impact of financial activities on communities, governments, future generations, and ecosystems. Financial institutions adopting this theory will invest in projects that balance profitability with

environmental and social benefits. For instance, banks may fund renewable energy projects even if returns are moderate, because the projects align with broader stakeholder interests like clean air and climate resilience.

This theory is foundational for the rise of Environmental, Social, and Governance (ESG) investing, where financial decisions are evaluated based on how well they serve various stakeholder groups.

Stakeholder Theory is a framework that expands the traditional view of business responsibility beyond shareholders to include a wide array of stakeholders—such as employees, customers, communities, governments, and the environment. In the context of green finance, the theory emphasizes that financial institutions and businesses have ethical and strategic obligations to consider the environmental and social impacts of their financial decisions. Rather than focusing solely on maximizing short-term profits, organizations are encouraged to make investments that promote long-term sustainability and benefit a broader set of stakeholders.

Green finance, under the lens of Stakeholder Theory, implies allocating capital to projects that contribute positively to environmental goals, such as reducing carbon emissions, conserving biodiversity, or enhancing climate resilience. Financial institutions that apply this theory are likely to support renewable energy, sustainable agriculture, clean transportation, and waste management projects. These investments may not always yield the highest immediate returns, but they align with the interests of multiple stakeholders—including future generations—by addressing pressing environmental challenges.

Stakeholder Theory also supports the integration of Environmental, Social, and Governance (ESG) criteria into investment decision-making. By assessing how companies manage environmental risks and treat various stakeholder groups, investors can make more informed, socially responsible decisions. In Nigeria, this perspective encourages banks, insurers, and development agencies to fund projects that promote sustainable development and mitigate negative environmental impacts, thus enhancing their reputation and long-term value creation.

Finally, the theory reinforces accountability and transparency in green finance. Since decisions affect a broad range of stakeholders, there is a moral and practical imperative for financial actors to report clearly on how funds are used and what environmental outcomes are achieved. This creates trust and encourages collaboration among stakeholders, including governments, civil society, and the private sector. Ultimately, Stakeholder Theory provides a strong ethical foundation for aligning finance with sustainable development goals.

Agency Theory

Agency theory explores the relationship between principals (e.g., shareholders or investors) and agents (e.g., company managers or project developers). In the context of green finance, it focuses on ensuring that agents act in the best interests of principals—particularly in sustainable investment practices.

One major concern is "greenwashing"—when companies or fund managers falsely claim that investments are environmentally responsible. Agency theory emphasizes the need for transparency, proper incentives, and monitoring mechanisms (like sustainability reporting) to align the goals of agents with those of environmentally conscious investors. This theory underlines the importance of disclosure, regulation, and third-party audits in green finance to ensure environmental claims are credible and performance meets investors' sustainability goals.

Agency Theory focuses on the relationship between principals (such as shareholders or investors) and agents (such as company managers or fund managers), where agents are expected to act in the best interests of the principals. In the context of green finance, this theory highlights the potential conflict between investors who want their funds used for sustainable, environmentally responsible projects and agents who may prioritize financial returns or personal gains over environmental outcomes. This misalignment can lead to inefficiencies and unethical behavior, such as "greenwashing"—misleading claims about the environmental benefits of an investment.

Green finance relies heavily on trust and transparency, and Agency Theory emphasizes the importance of mechanisms to ensure agents are held accountable. These mechanisms include regulatory oversight, performance-based incentives, ESG reporting standards, and independent audits. For example, a green bond issuer in Nigeria should be required to report on how the funds are used and what environmental impacts are achieved. This accountability helps investors verify that their capital genuinely contributes to sustainable outcomes, thereby reducing information asymmetry and agency risk.

In Nigeria's growing green finance landscape, applying Agency Theory can improve the credibility and efficiency of financial markets. It ensures that green investments are not only labeled as sustainable but are also managed and executed in a way that aligns with investor goals and environmental commitments. Strengthening governance structures, increasing transparency, and enforcing environmental disclosure are critical to ensuring agents remain faithful stewards of green finance capital. This, in turn, builds investor confidence and attracts more sustainable investments to Nigeria's economy.

Institutional Theory

Institutional theory posits that organizational behavior is shaped by the norms, rules, and structures of the institutional environment in which they operate. In green finance, this includes government policies, international agreements, cultural expectations, and industry standards.

The rise of global frameworks like the Paris Agreement or the EU Green Taxonomy encourages financial institutions to adopt green practices. In Nigeria, institutions may align with green finance principles because of pressure from global development partners, regulatory shifts, or reputational considerations. This theory explains why green finance grows more rapidly in countries with strong environmental regulations, active civil society, and international cooperation. It also suggests that changes in policy and institutional norms can accelerate the adoption of green finance.

Institutional Theory examines how organizational behavior is influenced by the formal and informal rules, norms, and expectations within a society or industry. In the context of green finance, this theory suggests that financial institutions and businesses adopt environmentally sustainable practices not only for economic reasons but also to conform to societal expectations, regulatory pressures, and global environmental standards. In Nigeria, the growing emphasis on sustainability by international partners, development agencies, and regulators is shaping how financial actors approach green investment.

As global agreements like the Paris Climate Accord and international frameworks like the UN Sustainable Development Goals gain traction, Nigerian financial institutions are increasingly pressured to align with these standards. Institutional Theory explains how this pressure—whether through government regulation, peer benchmarking, or access to international funding—can lead organizations to adopt green finance practices. For example, a Nigerian bank may integrate environmental risk assessments into its lending criteria not only out of environmental concern but also to meet requirements set by international investors or to maintain a competitive reputation.

In Nigeria, where environmental governance is still evolving, institutional forces such as donor expectations, industry standards, and partnerships with global financial bodies play a vital role in promoting green finance. This theory underscores the importance of creating strong regulatory frameworks, transparent policies, and active public discourse around sustainability. By embedding green finance into national institutions and financial norms, Nigeria can foster a stable and supportive environment for sustainable investment, ensuring that green finance becomes standard practice rather than a niche initiative.

Empirical Review

The burgeoning scholarship on green finance highlights a clear, albeit heterogeneous, positive association between environmentally focused financial instruments and economic growth, yet important methodological and contextual gaps remain. Jian and Hai (2024), using fully modified OLS (FMOLS) on a panel of 31 OECD countries (2010–2021), demonstrate that expanding green finance markets and attracting environment-oriented FDI significantly boosts long-run growth. However, their approach abstracts from short-run dynamics and country-specific equilibria, limiting direct applicability to emerging economies like Nigeria.

Mohsin, Iqbal, and Iram (2024) employ threshold regression to uncover nonlinear effects of green spending, finding robust long-term positive impacts. While illuminating potential "tipping points," threshold models do not capture how quickly economies adjust to equilibrium after shocks—an issue better addressed by autoregressive distributed lag (ARDL) techniques. Singh and Mishra (2024) extend the analysis to 30 countries during the COVID-19 crisis and report persistent positive growth effects of green financing despite pandemic disruptions. Yet their cross-sectional snapshot cannot disentangle immediate from longer-term settlement toward growth paths.

In the OECD context, Umar and Safi (2023) apply movement quantile regression (MMQR) to show that green finance reduces CO_2 emissions most effectively in higher-decile quantiles, underscoring the need for transparency and social inclusion to broaden impact. Focusing narrowly on China, Wang and Fan (2023) identify specific green finance instruments—particularly bonds—that mitigate investment risk and guarantee returns, boosting investor appeal. Shang et al. (2023) similarly document that green bond issuance enhances long-term efficiency in China's tourism sector, although these single-sector studies do not generalize to macroeconomic growth.

Conceptual work by Akomea-Frimpong et al. (2022) outlines regulatory clarity, market transparency, and social awareness as critical success factors for green finance initiatives but stops short of empirical testing. Global panel analyses by Wang et al. (2022) and Pang et al. (2022) affirm that green finance accelerates sustainability outcomes and green capital accumulation, yet reveal that efficacy varies dramatically with financial sector development and regulatory quality. Rahman et al. (2022), through content analysis of diverse green-finance criteria, further corroborate a positive green finance–growth linkage but emphasize the need for standardized measurement frameworks.

At the country level, Ngo et al. (2021) apply the ARDL bounds-testing methodology to Vietnam (1986–2019), successfully distinguishing short- and long-run effects of green investment and lending on GDP. Liu et al. (2020) use entropy methods in China to show that green credit, insurance, and investment jointly support growth. Crucially, no existing study employs an ARDL framework to assess how green bonds, loans, and insurance simultaneously affect Nigeria's economic trajectory.

The mixed findings and methodological diversity in the extant literature—particularly the absence of a unified ARDL analysis in a Nigerian context—motivate this study. By applying the ARDL bounds-testing approach to multiple green finance instruments in Nigeria (2005–2022), our research will capture both immediate adjustment speeds and long-run equilibrium relationships, thereby offering more nuanced and actionable policy guidance than previously available.

III. Data And Method

Data

The study employed annual time series data, through secondary source, on gross domestic product per capita (GDPP) to measure economic growth, Green Bonds Issued (GBI), Green Loan Finance (GLF) and Green Risk Insurance (GRI). The data were sourced from World Development Indicator (WDI) various years.

To examine the impact of green finance on economic growth in Nigeria, the study is modelled after that of Ngo, Doan, Vo, Tran and Nguyen (2021) with some modifications. In their study:

$$EG_t = \alpha_0 + \beta_1 GL_t + \beta_2 GINV_t + \beta_3 URIR_t + \beta_4 PCE_t + \varepsilon_t \quad - \quad - \quad - \quad (1)$$

Where:
EG is the economic growth,
t is the time period,
GL is the green loan,
GINV is the green investment,
URIR is the urban-rural Income Ratio,
PCE is the per capita expenditures.

In this study, some modifications were made to capture the time series component of the variables and to give more attention to green financing. Therefore, the functional form of the model is as follows:

$$GDPP_t = \beta_0 + \beta_1 GBI_t + \beta_2 GLF_t + \beta_3 GRI + U_t \quad - \quad - \quad - \quad (2)$$

The equation 2 can be presented in a log form as shown below:

$$\ln GDPP_t = \beta_0 + \beta_1 \ln GBI_t + \beta_2 \ln GLF_t + \beta_3 \ln GRI_t + \varepsilon_t \quad - \quad - \quad - \quad (3)$$

Where:

$\ln GDDPP_t$ = log of gross domestic product per capita

$\ln GBI_t$ = log of green bond issued

$\ln GLF_t$ = log of green loan finance

$\ln GRI_t$ = log of green risk insurance

β_1 *to* β_3 are the parameters to be estimated.

β_0 = Intercept of the entire regression model

ε_t = Stochastic error term

In line with the argument of Khan and Rose (1977) regarding the functional form of the model, all the variables are in their natural logarithm form in a log-linear specification. According to them, a log-linear specification is better than a standard linear one on both empirical and theoretical ground. That is, the log-linear specification allows the dependent variable to react proportionally to an increase or decrease in the regressors and exhibits interaction between elasticities. In addition, the variables are linearized and it leads to a reduction in the scale of measurement.

This research work used a relatively new estimating technique popularized by Auto-Regressive Distributed Lag (ARDL) approach developed by Pesaran and Shin (1999) and Pesaran, Shin and Smith, (2001). It is a general dynamic specification which uses the lags of the dependent variable and the lagged and contemporaneous values of the independent variables, through which the short-run effects can be directly estimated, and the long-run equilibrium relationship can be indirectly estimated. Apart from being efficient and consistent in cases involving small samples, the ARDL approach has the ability to handle situations where the variables of interest to the researcher are *I(0), I(1)* or fractionally integrated. However, this technique collapse if any variable is of I*(2).* ARDL also generates both short-run and long-run coefficient simultaneously. Moreover,

this approach can distinguish dependent and independent variables. In addition, different variables can be assigned different lag lengths as they enter the model. The ARDL form of equation 1 is specified as:

$$\Delta \ln GDPP_t = \beta_0 + \sum_{i=1}^{N} \beta_1 \Delta \ln GDPP_{t=i} + \sum_{i=0}^{N} \beta_2 \Delta \ln GBI_{t=i} + \sum_{i=0}^{N} \beta_3 \Delta \ln GLF_{t=i} + \sum_{i=0}^{N} \beta_4 \Delta \ln GRI_{t=i}$$

$$+\lambda_1 \ln GDPP_{t-1} + \lambda_2 \ln GBI_{t-1} + \lambda_3 \ln GLF_{t-1} + \lambda_4 \ln GRI_{t-1} + \varepsilon_t \text{ - } \quad \text{ - } \quad (4)$$

Where; $\ln GDPP_t$ is natural logarithm of gross domestic product per capita, $\ln GBI_t$ is natural logarithm of green bond issued, $\ln GLF_t$ is natural logarithm of green loan finance, $\ln GRI_t$ is natural logarithm of green risk insurance. β_0 and ε_t represents constant and Gaussian white noise respectively and $\beta_1, \beta_2, \beta_3, and\ \beta_4$ are the short run parameters (coefficients) of independent variables to be estimated.

Theoretically, the a priori expectation of the model are $\beta_1 > 0$, $\beta_2 > 0$, $\beta_3 > 0$, $\beta_4 < 0$. The expressions from β_1 to β_4 with the summation signs represents the short-run dynamics of the variables where lag values are included while λ_1 to λ_4 depicts the long-run relationship between the variables (long run coefficients).

The existence of a long-run relationship among gross domestic product per capita, green bond issued, and green risk insurance is examined by Bounds test. In the first stage, the null hypothesis of no co-integration of equation (4), $H_0 : \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = 0$ is tested against the alternative $H_1 : \lambda_1 \neq \lambda_2 \neq \lambda_3 \neq \lambda_4 \neq 0$.

This test is performed on the basis of comparing the computed F-statistic values with bounds on critical values which depend on the number of variables. If the calculated F-statistic is higher than the upper bound critical values *I(1)* for the number of explanatory variables (k) by Pesaran, Shin and Smith, (2001), the null hypothesis will be rejected, indicating co-integration. The upper bounds critical value is based on the assumption that all the variables are *I(1).* On the other hand, if the F-statistic is lower than the lower bound crucial value *I(0),* null hypothesis cannot be rejected. This indicates no co-integration. The lower bounds critical value is based on the assumption that all the variables are *I(0).* However, the F-statistic being between *I(0)* and *I(1)* presents an in conclusive result.

In the second step, the parsimonious model i.e the model with minimum information Criteria or the maximum R-square value is determined using the three-lag selection criterion namely, Akaike's Information Criterion (AIC), Schwarz Bayesian criterion (SBC) and R-squared Criterion to obtain appropriate lag length. This exercise is important because only an appropriate lag selection will be able to identify the true dynamics of the model.

The following error correction model is estimated in the third step.

$$\Delta \ln GDPP_t = \beta_0 + \sum_{i=1}^{N} \varpi_i \Delta \ln GDPP_{t-1} + \sum_{i=1}^{N} \varphi_i \Delta \ln GBI_{t-1} + \sum_{i=1}^{N} \Omega_i \Delta \ln GLF_{t-1} + \sum_{i=1}^{N} \Upsilon_i \Delta \ln GRI_{t-1}$$

$$+\Psi ECM_{t-1} + V_t \quad . \quad . \quad . \quad (5)$$

Where $\Delta \ln GDPP_t = GDPP_t - GDPP_{t-1}$, and ditto to all other explanatory variables, β_0 is the constant, $\varpi_i, \varphi_i, \Omega_i, and\ \gamma_i$, are the dynamic adjustment coefficients, ECM_{t-1} is the lag of residual representing short run disequilibrium adjustments of the estimates of the long run equilibrium error, and Ψ is the coefficient of the error correction term, while V_t is the random error term. The error correction coefficient must be negative and statistically significant which indicates the existence of a short-run relationship. The size of the error correction coefficient determines the speed of adjustment towards equilibrium.

IV. Empirical Results

Unit Root Test Result

As stated in the previous section, one of the major short coming of ARDL approach is its inability to handle situations in which variable(s) is/are *I(2)* or higher. To be sure that the variables under study are only of *I(0)* and *I(1),* the popular Philips-Perron stability test is carried out to test for unit root. The result is presented in table 1:

Table 1: Phillips-Perron Unit Root Test Results:

Philips-Perron							
	LEVELS			FIRST DIFFERENCED			
Variable	t-statistic	Critical value	p-value	t-statistic	Critical value	p-value	*I(d)*
Log(GDPP)	-0.254210	-2.945842	0.9220	-6.336371	-2.948404	0.0000 **a*****	*I(1)*
Log(GBI)	-2.206131	-2.945842	0.2077	-5.11589	-2.948404	0.0002**a*****	*I(1)*
Log(GLF)	-5.063835	-2.945842	0.0002**a*****	-	-	-	*I(0)*
Log(GRI)	-2.704263	-2.1945842	0.00831	-7.950158	-2.948404	0.0000 **a*****	*I(1)*

Source: Researcher's computation (2025) using E-view 10.0

Note: *** and ** imply statistical significance at 1% and 5% levels respectively.

Also, '*a'* denotes model with constant.

The results as presented in table 1 revealed that gross domestic product per capita (GDPP), green loan issued (GLI) and green risk insurance (GRI) have unit root problem at their levels but are integrated of order one using Philips-Perron tests. While green loan finance (GLF) is stationary at level, *I(0)*. The results of the unit root test has necessitated the co-integration test as well as the choice of ARDL model because consumer price index is *I(0)* while other variables are *I(1).*

Bounds Testing Approach for co-integration

Equation 2 is used in testing for co-integration using ARDL bound test. The null hypothesis of no co-integration $H_0 : \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = 0$ is tested against the alternative hypothesis $H_1 : \lambda_1 \neq \lambda_2 \neq \lambda_3 \neq \lambda_4 \neq 0$. The result is presented in table 2.

Table 2: Co-integration Test Result:

Test Statistic	Value	K
F-statistic	5.222612	3
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.72	3.77
5%	3.23	4.35
2.5%	3.69	4.89

Source: Researcher's computation (2025) using E-view 10.0

The result as presented in table 2 shows that the computed F-statistic of 5.222612 is far above the upper bound critical values of 3.77, 4.35 and 4.89 for 10%, 5% and 2.5% respectively as suggested by Pesaran et al (2001).

This is an evidence of strong long-run relationship between and among green bond issued, green loan finance as well as green risk insurance and gross domestic product per capita in Nigeria based on the data and the period used. In order words, there is long-run co-integration between and among the variables. The implication of the existence of cointegration is that any of the regressor variable can be targeted as a policy variable to bring about the desired changes in dependent variable in the system (Asongo, 2019). Therefore, green bond issued, green loan finance as well as green risk insurance are long run determinants of economic growth in Nigeria.

Long- Runs ARDL Estimates

Using the Schwarz Bayesian criterion (SBC) lag selection criterion to obtain appropriate lag length the E-views 10.0 software suggested the model of ARDL (1,1,0,0) as parsimonious.

The result of long- run estimates is presented in Table 3.

Table 3: Long- run (ARDL 1, 1, 0, 0) results for economic growth model in Nigeria

Long Run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(GBI)	0.108912***	0.025039	4.349701	0.0001
LOG(GLF)	0.068543***	0.034184	2.005108	0.0170
LOG(GRI)	0.201171	0.173889	1.156892	0.2564
C	8.414617	0.418531	20.105143	0.0000

Source: Researcher's Computation (2025) Using E-views 10.0

*Note: ***and ** signifies 1% and 5% levels of significance respectively.*

For the fact that a cointegration relationship was detected between the series, ARDL models were established to determine the long- and short-term relationships. According to Pesaran and Shin (1999), the SBC

is generally preferred to other criteria because it tends to define more parsimonious specifications with the limited observation. This study used the SBC to select appropriate lags for the ARDL models which is found to be the order of ARDL (1, 1, 0, 0).

In terms of direction of relationship, there is a positive relationship between all the regressors (green bond issued, green loan finance and green risk insurance) and economic growth. This means that increase in any of these variables will result to increase in economic growth. Green bond issued and green loan finance is positive and statistically significant in explaining the variation in economic growth. Green risk insurance is however positive but statistically insignificance in explaining the variation in economic growth. Precisely, increase in green bond issued by one percent will significantly increase economic growth by about 11 percent and it stands inelastic. Increase in green loan finance by one percent will result to a significant increase in economic growth by about 06 percent in the long-run. It is also inelastic. Increase in green risk insurance by one percent will insignificantly increase economic growth by about 20 percent in the long-run.

Short-Run ARDL Estimates

Table 4: Short-run (ARDL 1, 1, 0, 0) results for economic growth model in Nigeria

Cointegrating Form				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG(GGBI)	0.105537**	0.045248	2.332434	0.0266
DLOG(GLF)	0.023918**	0.010844	2.205699	0.0352
DLOG(GRI)	0.070197	0.054592	1.285853	0.2083
CointEq(-1)	-0.348943***	0.093270	-3.741226	0.0008

R-squared	0.961348	Mean dependent var	9.121970
Adjusted R-squared	0.954906	S.D. dependent var	0.278920
F-statistic	149.2299	Durbin-Watson stat	1.737085
Prob(F-statistic)	0.000000		

Source: Researchers computation (2025) using E-view 10.0
*Note: ***and ** signifies 1% and 5% levels of significance respectively.*

The results of the short-term dynamic coefficients associated with the ARDL specifications are presented in tables 4. The last line presents the error correction terms (CointEq(-1)) related to the cointegration vector. It indicates that short-term relationships are satisfactory because the error correction term is significant and exhibit the expected negative sign. This coefficient corresponds to the speed of the adjustment to equilibrium level due to short-run shocks. Thus, higher values of that coefficient are associated with more rapid adjustments. The significant and negative magnitude of the ECT, of −0.348943 reflects a rapid speed of adjustment. This implies that about 35% of the disequilibria of the previous year's shock adjusting back to the long run equilibrium in the current year. This economic growth equation revealed that any deviation from the long run equilibrium is recovered in 2.9 months (1/0.34). This support the result of the co-integration test. Consequently, green bond issued, green loan finance and green risk insurance will play important roles to absorb any negative shock to economic growth in Nigeria. Just like in the case of long run, the variables are positively signed. Again apart from green risk insurance which have positive but insignificant impact on economic growth and stand inelastic, green bond issued and green loan finance have positive and significant relationship with economic growth and stand inelastic. The magnitude of the long-run coefficients are larger than those of the short-run revealing that the impact of green finance is more in the long-run than in the short-run. This calls for long-run green finance policies that will stimulate economic growth.

The adjusted R-squared value of 0.961348 indicates that about 96 percent of the variation in economic growth is explained within the model and only about 4 percent that is explained by the variables outside the model. Durbin-Watson value of approximately 2 confirm the absence of serial correlation. The probability value of F-statistic shows that, as a whole, the model performs well.

Post-Estimation Tests:

Linearity Test:

Table 5: Ramsey RESET Test				
	Value	Df	Probability	
t-statistic	2.208984	29	0.1352	
F-statistic	4.879612	(1, 29)	0.2352	

Source: Researcher's Computation (2025) Using E-view 10.0

Ramsey's RESET statistic is reported to judge misspecification. Given its probability value of 0.1352 and 0.2352 for t-statistic and F- statistic respectively, the RESET statistics are highly insignificant, supporting correct specification of the model.

Serial Correlation Test:

Table 6: Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.268732	Prob. F(2,28)	0.7663
Obs*R-squared	0.678011	Prob. Chi-Square(2)	0.7125

Source: Researcher's Computation (2025) Using E-view 10.0

A key assumption in the bounds testing methodology of Pesaran et al. (2011) is that the errors must be serially independent. To make sure residuals of the optimum model are autocorrelation free, the researcher reported the Breusch-Godfrey Lagrange Multiplier (LM) statistic. The LM statistic is insignificant at 1% since the probability values of 0.7663 and 0.7125 for F-statistic and Obs*R-squared respectively are higher than 0.1. Therefore, there is no evidence of serial correlation.

Heteroskadasticity Test:

Table 7: Heteroskedasticity Test: ARCH			
F-statistic	0.240740	Prob. F(1,33)	0.6269
Obs*R-squared	0.253481	Prob. Chi-Square(1)	0.6146

Source: Researcher's Computation (2025) Using E-view 10.0

Table 7 presents the results of heteroskedasticity test. The P-values of 0.6269 and 0.6146 for F-statistic and Obs*R-squared from Breusch-Pagan-Godfrey ARCH is in support of the null hypothesis of no evidence of heteroskedasticity. That means that the residuals are homoskedastic.

V. Conclusion

This research work empirically examined the impact of green finance on economic growth in Nigeria using annual time series data obtained from world development indicators. Unit root tests (PP tests), and co-integration test (Bounds Test) were carried out to ascertain the stationarity and to know the existence of long-run relationships between green finance and economic growth respectively. Error correction model was carried out to test the power of adjustment to long run equilibrium due to short run shock. The speed of adjustment of 0.35 is found to be very high. The results of the unit roots test indicated that apart from green loan finance which is stationary at levels, all other variables are stationary in first differences *I(1).* The co-integration tests results showed that long-run relationships exist between the green finance and economic growth. Error correction method is used to estimate the short-run relationship between green finance and economic growth.

Green bond issued and green loan finance are individually positive and statistically significant in explaining variation in economic growth both in the short-run and the long-run. This implies that increased green finance for production purposes could have significant impact on economic growth both in the short-run and in the long-run. Green risk insurance on the other hand reported a positive but insignificant relationship in explaining changes in economic growth in Nigeria. Therefore, green finance is found to have positive and significant impact on economic growth in Nigeria.

Battery of diagnostic tests was also applied to the empirical models to gauge the adequacy of the models' specifications. The Breusch–Godfrey LM test statistic rejects the hypothesis of serial correlation for the equations. The ARCH test confirms that the residuals are homoscedastic in all equations, and the Ramsey Reset test confirms the correct functional form of the equations.

The significance of green finance in addressing adverse climate issues is evident in its ability to channel investment into environmentally responsible projects. Since green finance has potentials of causing significant environmentally friendly economic growth in Nigeria, the study recommended the need for financial institutions to incorporate climate related factors into their loan decision making process as well as increase the percentage of their profit to green loan financing.

Government should strengthen regulatory framework that support green finance including promoting green risk insurance among individuals and corporate bodies. In another dimension, public-private partnership is required in building the infrastructure and trust necessary for scaling green finance solutions.

Generally, the government of Nigeria should issue more green bonds and make it more attractive to all economic agents to increase the pool of green finance. It should appropriately apportioned some percentages of federal allocation to local government specifically for green financing. This will expand its scope to the grass-roots.

Additionally, each region should take full advantage of local and natural endowment to identify environmental friendly investment that can guarantee economic growth. Green financing should be channeled to such investments.

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