Modern Finance

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Sustainable development in emerging economies: Comparing the impacts of green finance and financial inclusion

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Abstract: The study compares four independent estimation techniques, the panel ARDL, FMOLS, DOLS (non-distributional), and quantile regression (distributional), examining the comparative impacts of green finance and financial inclusion in twelve emerging economies of the world based on data from 2014 to 2023. The estimates were unanimously used to justify the undeniable influences of green finance and financial inclusion on sustainable development. The results from the non-distributional techniques revealed that green finance and financial inclusion significantly positively impacted sustainable development in emerging economies. The quantile regression results showed that financial inclusion was more beneficial to sustainable development than green finance, although it was around the middle of the distribution. The quantile regression output further proved that the relationship between sustainable development and green finance in emerging economies is weaker than that between financial inclusion. According to these findings, green financial inclusion holds the potential to advance the achievements of sustainable development in emerging economies.

Keywords: sustainable development, green finance, financial inclusion, emerging economies, dynamic panel analyses

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Citation: Epor, S.O., & Akande, J.O. (2025). Sustainable development in emerging economies: Comparing the impacts of green finance and financial inclusion. *Modern Finance*, *3*(4), 1–21.

Accepting Editor: Adam Zaremba

Received: 24 February 2025
Accepted: 1 October 2025
Published: 3 October 2025

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1. Introduction

This research evaluates the distinct relationship between green finance and sustainability, following Sohail, Haddad et al. (2024), who proposed additional studies on green finance and the sustainability nexus to advance a more global understanding of new concepts. The emerging economies have shown appreciable improvements in economic growth backed by large productive and industrial bases. Besides, the world's emerging economies have a high proportion of the global population and market. These countries have the attributes of a growing population, but infrastructure, regulation, governance, inequality, poverty, and institutional quality are lagging. This situation raises concerns about the overall living standards of the people there. Based on these, these countries' environmental and social aspects have become a challenge calling for urgent action (Yeboah, Abbass et al. 2024). Sustainable development, as a composite concept, integrates the improvements in social and environmental as well as economic well-being of a country (Denu, Bentley et al. 2023, Alam, Dinçer et al. 2024, Amaliah, Ali et al. 2024, Yeboah, Abbass et al. 2024, Bouguerra, Cakir et al. 2025). The fact that emerging economies occupy very significant economic positions in the global economy makes studies that dwell on sustainable development in these countries a burning global issue.

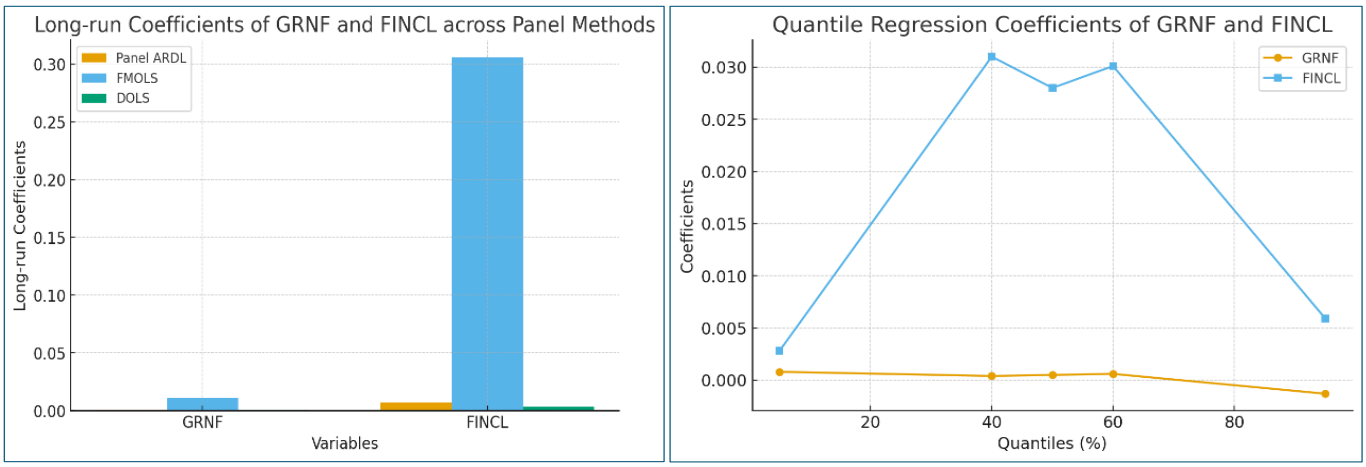
Among the notable factors that determine sustainable development are green finance and financial inclusion, which are capable of impressing their significance in countries worldwide. The dependence of sustainable development on green finance is rooted in literature because of its ability to promote several social and environmental benefits it

brings (Gharleghi et al., 2024; Huang, 2024; Sharma, 2023; Nikolić & Milojković, 2023). Since it funds eco-friendly projects, its environmental benefits include reduced greenhouse gas emissions, improvement in corporate social responsibility, and energy efficiency, which are connected to support sustainable development (Yadav et al., 2024). Besides the benefits, green finance needs a supportive financial system, lacking in emerging economies. Due to their underdevelopment, there is no gainsaying that emerging developing economies need to develop policies of financial inclusion to develop their financial system. Green finance will need a developed financial system through grounded financial inclusion to attain sustainable development in emerging economies. While it is appreciated that the global green initiatives are beneficial to sustainable development (Agrawal & Magar, 2024), such benefits can only reach the world's vulnerable populations with financial inclusion (Edet et al., 2024). So, on the access to wider financial services, sustainable development can leverage financial inclusion digital and fintech platforms (Danladi et al., 2023; Gigauri et al, 2023) and green investments (Ozili, 2023) to advance the sustainability of emerging economies.

The objective of comparing the influences of green fiancé and financial institutions on sustainable development in emerging economies comes from the necessity to address how these countries have performed low in terms of sustainability indicators and low level of green finance interventions, shown by the small scale or late commitments to green bonds in Brazil, India, Malaysia, Mexico and South Africa (IMF, 2024). Although green finance holds the potential to advance environmental sustainability, the low implementation of these financial instruments in emerging economies raises significant concerns about its effectiveness in reversing the dwindling developmental status of these countries. Instead, financial inclusion, which has demonstrated tremendous ability for wider usage, can be used to advance sustainable development on account of its wide social benefits that align with the triple bottom line of environmental, social, and economic development (Tidjani & Madouri, 2024; Robles et al., 2024; Sardar & Batul, 2024; Wang et al., 2022a). Considering that financial inclusion and green finance are emerging financial innovation concepts, comparing their relative impact will provide a platform to see how they complement or differ in enabling sustainable development. Furthermore, while financial inclusion may be more effective in achieving inequality reduction, improved productivity, and inclusive growth, it also has some environmental threats in developing countries, such as increased demand for fossil energy that can divert the sustainable development direction (Saqib et al., 2023). Therefore, establishing that neither green finance nor financial inclusion is exclusive of issues on the path to sustainable development.

Comparing the findings of the panel ARDL, FMOLS, and DOLS showed that both green finance and financial inclusion advanced sustainable development in emerging economies in the long run. However, the influence of financial inclusion was consistently larger than that of green finance. This means that the influence of financial inclusion was more beneficial to sustainable development than green finance. However, the distributional effects from the quantile regression model showed that the benefits of financial inclusion were significant at the middle quantiles or middle levels of sustainable development, below or above which there is no capacity for financial inclusion to drive significant influences. In contrast, green finance was found to be non-beneficial to the different distributions of sustainable development. This implies a weaker relationship with sustainable development than that which was discovered with financial inclusion.

Figure 1. Results Estimates of Green Finance (GRNF) and Financial Inclusion (FINCL)



Note: This figure represents non-distributional (that is, panel ARDL, FMOLS, and DOLS) and the panel quantile regression output. Quintile 5 contains emerging economies with the lowest sustainable development scores, while quintile 95 contains those with the highest sustainable development scores. The coefficients are present in the vertical section. The sample consists of 120 observations, and the sample period is from 2014 to 2023.

The study makes some appreciable contributions to knowledge by examining the comparative roles of green finance and financial inclusion on sustainable development with non-distributional techniques, that is, panel ARDL, FMOLS, and DOLS, and a distribution-based panel quantile regression technique. The finding that financial inclusion and green finance significantly support sustainable development is not new, as Oanh (2024) had earlier established. However, our study extended this finding to reveal that financial inclusion was more beneficial in magnitude to sustainable development than green finance was. Conversely, the enabling nature of green finance for sustainable development is similar to the position of Lin et al. (2023), who associated green finance with economic and social sustainability, placing it in a context beyond the traditional environmental basis. The distributional result with panel quantile regression agrees with the position of Mo et al. (2023), Addai et al. (2024), and Kwilinski et al. (2023), who established the misleading conclusion that will emerge from assuming homogeneous and uniform effects from green finance from all countries and sectors. This study's quantile result empirically proved this claim. In fact, this study established that the current level of green finance is detrimental to higher-performing emerging economies. The poor effectiveness of green finance has been highlighted earlier by Sahu and Khatri (2024), Shi et al. (2024), and Zhang (2024), but in the context of governance challenges and credit accessibility issues. In contrast, the multidimensional concept of financial inclusion as an enabler of sustainable development is also supported in this study. This aligns with Danladi et al. (2023), Robles et al. (2024), and Machaca et al. Sadar and Batul (2024), Abramova et al. (2021), and (2024) associated financial inclusion with inclusive development drivers like poverty alleviation, financial literacy, and rural development. However, the empirical claim of the uniform influence of financial inclusion on sustainable life in sub-Saharan Africa by Tidjani and Madouri. (2024), Markjackson and Agada (2024), and Nantharath et al. (2023) were challenged with the distribution-based quantile regression results. The levels of financial inclusion are only relevant to middle-performing countries, that is, between 40% to 60%, of sustainable development scale. This also means that financial inclusion frameworks in emerging economies are not sufficient for all levels of development. In this regard, studies like Gigauri et al. (2023) and Barkat et al. (2024) argued that the effectiveness of financial inclusion relies on a structural and institutional environment based on their findings that the rule of law and remittances complement the role of financial inclusion to drive sustainable development. Similarly,

the current study adds to the literature by showing that the role of financial inclusion is significant only around the median level of sustainable development, beyond which it is not significant. Further, Nantharath et al. (2023) emphasized that more will be achieved in sustainable development if emerging and developing economies embark on continuous financial and institutional reforms.

Notably, the paper is a valuable contribution to the discussion about the relationship between green finance and financial inclusion because it demonstrates that the two do not necessarily exclude each other. However, there is even a possibility of synergy. The study conducted by Chen (2023) showed that combining the two with eco-innovation can enhance sustainable results, consistent with the works of Ozili (2023), who distinguished their works in the context of economic, social, and ecological sustainability. Moreover, the results of the panel quantile regression are the first of their kind since they demonstrate that green finance has a weak impact at low-to-middle levels of sustainable development and can have a negative impact at advanced levels, which D'Orazio and Dirks (2022) also predicted due to transitional cost regulations in high-performing economies. Conversely, financial inclusion was more helpful in the case of middle-performing economies, but not in the extremes, which is also consistent with Iddrisu et al. (2022) and Demir et al. (2020), who attributed structural barriers and income inequalities to the conditionalities of the impacts of inclusive finance on sustainable development.

After the introduction section, the other parts of the study are sectionalized into four parts. The second section is devoted to handling literature review, which contains brief conceptual reviews, theoretical reviews, and a review of past empirical studies. Section three deals with the data and methodology adopted for estimating the model of the study. The results and associated discussion are in the fourth section, while the fifth section is for the conclusion and recommendations.

2. Literature Review

The theories that relate green finance to sustainable development accommodate environmental factors in economic advancements. The principles of green finance theory suppose that when financial systems are centred on creating investments for clean technologies and renewable energy, they are sustainable (Ansari et al., 2024). As proposed by the Paris Climate Change Agreement, financial support for environmental sustainability has green finance as one of the remedial action plans (Edet et al., 2024). This makes green projects, which retain values for future generations, the connecting bond between green finance and sustainable development (Agrawal & Magar, 2024). Besides green finance, financial inclusion promotes sustainable development because of its relevance to inclusive growth, tackling inequality, and promoting social justice (Orekoya, 2020). The role of financial inclusion is theoretically explained by the resource efficiency theory, which conceptualizes that financial inclusion and green growth originated from the discussion on sustainable development. This theory holds that it is impossible to separate financial inclusion from sustainable development. With more access to conventional and greener financial products, individuals and businesses are empowered to invest in green technologies and outputs that are favourable to the environment (Tidjani & Madouri, 2024; Amaliah et al., 2024; Samson & Ndefru, 2024; Wang et al., 2022a).

Again, the diffusion theory proposed by Everett Rogers is another way to explain the link between green finance and financial inclusion on the path to sustainable development, which involves innovation. The theory, which has its basis in economic, environmental sciences, and innovation principles, explains that financial inclusion uses diffusion of green financial innovation and technologies to advance sustainable development (Samour et al., 2024; Abbas et al., 2024). With financial inclusion, businesses and entrepreneurs have more access to newer financial services and are empowered to commit to newer, cleaner technologies that align with those financial initiatives (Oanh, 2024). As an innovative financial instrument for a greener society, green finance tends to

align with financial inclusion here to foster a common goal: sustainable development. Based on the innovation and diffusion theory, thinking of the synergic influences of green finance and financial inclusion on sustainable development is somewhat tempting. However, being guided explicitly by the objective of this study, we will rely on the innovation and diffusion theory framework to consider the independent roles of financial inclusion and green finance on sustainable development in emerging economies.

2.1 Green finance and sustainable development

The empirical reviews for this study, which tries to compare the influences of financial inclusion and green finance on sustainable development, can be categorized into two key perspectives. First of all, the empirical findings regarding how sustainable development is affected by green finance suggest how green finance has curtailed environmental degradation (Le et al., 2024; Yadav et al., 2024; Sohail et al., 2024; Jinping et al., 2024; Fu et al., 2024; Agrawal & Magar, 2024; Bhopal & Devi, 2023; Wang et al., 2022a; Nenavath & Mishra, 2023; Nikolić & Milojković, 2023; Fu et al., 2023). These studies mainly depend on bibliographic examination. In agreement, Lin et al. (2023) posit that green finance reform and innovation pilot zones supported the economic and social aspects of sustainable development.

In India, Sahu and Khatri (2024) used a qualitative approach to show that green finance is the key determinant of sustainability, but identified insufficient investment levels to achieve sustainable development objectives. Insufficient green finance is said to be more severe in developing countries than in advanced ones. Studies have been trying to unravel the cause of this. Due to the nascent nature of green finance, one sure reason is corruption. When corruption control is low, Shi et al. (2024) argued that green finance can significantly reduce greenhouse gas emissions. Zhang (2024) used Dynamic Ordinary Least Squares and fully modified ordinary least squares (FMOLS) econometric regression methods from 1990Q1 to 2022Q4 to reveal that increased access to credit facilitated the growth of green financing. Oanh (2024) data from 2005 to 2019, and the Bayesian regression revealed that financial inclusion boosted sustainable development by 100% and 88.34% in HFDCs and LFDCs, respectively. Sustainable development also benefited from the interaction of green finance and financial inclusion.

Shi et al. (2024) demonstrated that green finance significantly reduced greenhouse gas emissions when corruption control was strong or corruption levels were low. Addai et al. (2024) used the panel-corrected standard errors estimator for long-run co-integration to show that mitigated green finance (MGF) improved agricultural value added. Mo et al. (2023) used stepwise regression and bootstrapping to analyse the data from 30 Chinese provinces, 2011-2020, showing that green finance growth significantly influenced the agricultural sector. Kwilinski et al. (2023) used the spatial Durbin model to establish that green finance positively drives sustainable development, but is heterogeneous across different EU regions.

2.2 Financial inclusion role in sustainable development

The other strand of empirical studies relevant to this research is concerned with financial inclusion in determining sustainable development. By arguing along this line, many studies have supported the significant roles financial inclusion plays for improving sustainable development (Danladi et al., 2023; Robles et al., 2024; Machaca et al., 2024; Sardar & Batul, 2024; Abramova et al., 2021). Also, the financial inclusion policy strategy not only aligns with sustainable development goals but also does so through sustainable rural development, promoting financial education, and financial service awareness. Gigauri et al. (2023) found that the supportive roles of the rule of law and remittances need to be considered for financial inclusion to alleviate poverty. This potential of financial inclusion requires collaboration efforts between the government and the private sector. However, some counter studies showed otherwise. Although Ozili (2023) has

counter-argued that financial inclusion could improve economic and social welfare, it offered limited benefits for environmental sustainability. Wang et al. (2022b) revealed that financial inclusion improved environmental quality in China only at medium and high levels of financial development.

From arguing on the side of general sustainable development that includes economic, social, and environmental improvements, Oanh and Dinh (2024) observed a substantial positive impact of digital financial inclusion and stability on Vietnamese sustainable development, evident across various quantiles and frequencies. Barkat et al. (2024) revealed that financial inclusion acted as a mediating factor in the positive impact of remittances in achieving sustainable development goals in developing countries. Singh et al. (2022) confirmed that financial inclusion strongly supported sustainable development in India. The Bayesian ARDL method used by Chien (2023) demonstrated that financial inclusion with green investments and eco-innovation produces substantial improvements in Chinese sustainable development.

Using panel ARDL analysis, Markjackson and Agada (2024) investigated the effects of financial inclusion on sustainable living in 20 sub-Saharan African countries. The study established that financial inclusion significantly affected sustainable living in sub-Saharan Africa. Tidjani and Madouri (2024) used system GMM and static panel OLS, fixed effects, and least squares dummy variable on 25 African countries from 2011 to 2019 to show that financial inclusion and FinTech are positive drivers of sustainable development. With 48 sub-Saharan countries and panel VECM, Nantharath et al. (2023) found that financial inclusion positively and significantly influenced sustainable development in the long run of 2000-2021.

2.3 Gap in Literature

About the objective of our study, the empirical evidence has shown that limited studies address the comparison of green finance influence with financial inclusion on sustainable development, considering how prominently they support sustainable development. Studies that come close include Oanh (2024), on financial inclusion, green finance, and green growth relationships in heterogeneous countries at different levels of financial development. Chien (2023) showed that green investments, along with ecological innovation and financial accessibility, work together to boost Chinese sustainable development. However, the study lacks appreciable generalization based on the single-country scope. Determining which factor, between financial inclusion and green finance, possesses greater influence on sustainable development serves essential purposes for emerging economies. First, the drive for economic growth seriously challenges environmental sustainability in emerging economies (Bouguerra et al., 2024). Second, several emerging economies must investigate financial inclusion as a potential means of achieving sustainable development since their green finance levels remain low. The nations in this group have achieved progress through their policies regarding increased financial inclusion, particularly digital finance, according to Tidjani and Madouri (2024), Ansari et al. (2024), Oanh and Dinh (2024), and Amaliah et al. (2024). These two financial factors connect directly to create environmentally sustainable development opportunities because financial inclusion supports green investment resource mobilization, and green finance enables economic benefits for disadvantaged groups.

3. Methodology

3.1 Data and Measurement of Variables

The main objective of our study is to compare the impacts of green finance and financial inclusion on sustainable growth in emerging economies. Our study comprises data sourced from 12 emerging economies from 2014 to 2023. The choice of the countries was mainly due to data availability and their relevance to the objectives of this study. The

countries included are Brazil, Poland, Chile, South Africa, China, the Philippines, Colombia, Nigeria, India, Mexico, Mauritius, Indonesia, and Malaysia. The World Bank country classification guides this study as an emerging country. Besides, the choice of these countries is globally representative, cutting across four major continents: North America, South America, Europe, Africa, and Asia. The chosen countries are known to be exposed to various environmental, social, and economic issues that need to be reevaluated with green finance and financial inclusion. The World Development Indicators (WDI) database forms the source for the data.

Based on the study objective, our data includes sustainable growth and development (SDVT) as the dependent variable and green finance (GRNF) and financial inclusion (FINCL) as the independent variables. In contrast, economic growth (GDPK), population density (POPD), and foreign direct investment (FDI) are the study's control variables. Sustainable development is proxied by the composite index of the Sustainable Development Goals available from the SDG Transformation Centre (https://dashboards.sdgindex.org). The composite index accommodated the environmental, economic, and social well-being of countries, and so it is termed representative and comprehensive. Following the idea of composite index construction, this study used the Principal Component analysis to derive the index of financial inclusion from seven indicators: Number of ATMs per 100,000 adults, Number of deposit accounts with commercial banks per 1,000 adults, Number of commercial bank branches per 100,000 adults, Number of credit cards per 1,000 adults, Number of debit cards per 1,000 adults, Value of mobile and internet banking transactions (% of GDP) and Number of borrowers from commercial banks per 1,000 adults. Table 1 provides the construction of the financial inclusion index with the PCA technique.

Table 1. Principal Component Analysis for Financial Inclusion Index

Indicator	Eigenvalue	Diff.	Prop.	Cum. Value	Cum. Prop.
ATMs per 100,000 adults	3.271	2.292	0.467	3.271	0.467
Number of borrowers from commercial banks per 1,000 adults	0.979	0.067	0.140	4.251	0.607
Number of commercial bank branches per 100,000 adults	0.912	0.184	0.130	5.163	0.738
Number of credit cards per 1,000 adults	0.729	0.326	0.104	5.892	0.842
Number of debit cards per 1,000 adults	0.403	0.028	0.058	6.294	0.899
Number of deposit accounts with commercial banks per 1,000 adults	0.375	0.044	0.054	6.669	0.953
Value of mobile and internet banking transactions (% of GDP)	0.331	---	0.047	7.000	1.000

Note: Diff. = eigenvalue from one component to the next; Prop. = Proportion of Variance; Cum. Value = Cumulative Eigenvalue; Cum. Prop. = Cumulative Proportion.

The first principal component of financial inclusion, ATM access per 1000 adults, explains about 46.7 percent of the total weight. The second and third principal components of financial inclusion explain about 14.0% and 13.0% of the total weight, respectively. The proportion of adults with credit and debit cards is 5.8% and 5.4% of the total population, respectively. Finally, the value of mobile banking and internet banking accounts for about 4.7% of the total weight. Due to the significance of each financial inclusion indicator in explaining financial access, they will all be part of constructing the estimates of the composite index value for financial inclusion. Estimates of these indices range from approximately -2.5 (the lowest level of financial inclusion) to 2.5 (the highest level).

Many empirical literature that treated green finance and sustainable development (Zhang, 2024; Sahu & Khatri, 2024; Oanh, 2024; Shi et al., 2024; Le et al., 2024) and financial inclusion and sustainable development (Markjackson & Agada, 2024; Oanh & Dinh, 2024;

Amaliah et al., 2024; Ansari et al., 2024; Barkat et al., 2024; Tidjani & Madouri, 2024; Samour et al., 2024) have used the data adopted in this study. The study relied on twelve emerging cross-country panel data from 2014 to 2023. We also included control variables to help us ensure that the impacts of financial inclusion and green finance on sustainable development are isolated. The inclusion of economic growth (GDPK), population density (POPD), and foreign direct investments (FDI) as this study's control variables is justified by previous literature. Economic growth captures the country's overall economic progress, the primary reason to consider whether the growth is sustainable or not (Amaliah et al., 2024). Also, foreign direct investment represents capital inflows that support sustainable innovation and infrastructures (Shi et al., 2024; Mo et al., 2023). Population density is justified because population exerts pressure on wellbeing and is the basis for measuring the sustainability of any kind (Oanh, 2023; Mo et al., 2023). Table 2 provides definitions of variables and their sources based on the literature as follows:

Table 2. Variables and their sources.

Variable	Acronym	Description	Source
Dependent Variable			
Sustainable development	SDVT	The composite index of all 17 sustainable development goals captures economic, social, and environmental dimensions of lives.	World Bank
Independent Variable			
Green finance development	GRF	Financial initiatives that support environmental sustainability, in this case, the ratio of green bond to GDP ratio	IMF Climate Dashboard
Financial inclusion	FINCL	Principal Component of seven financial access indicators	PCA from WDI
Control Variables			
Economic growth	GDPK	Per output as measured by GDP per capita in US dollars	WDI
Population density	POPD	Population divided by land area in square kilometers	WDI
Foreign Direct Investment	FDI	Net inflows of all foreign direct investment countries divided by GDP	WDI

3.2. Model Specification

This study uses the quantitative approach, beginning with describing financial inclusion, green finance, and sustainable development. Further to the quantitative analysis, this study applies appropriate econometric methods to examine how financial inclusion and green finance determine sustainable development. Following the tested empirical models of closely related literature (Oanh, 2024; Shi et al., 2024; Le et al., 2024; Markjackson & Agada, 2024; Oanh & Dinh, 2024; Amaliah et al., 2024), the general form of the econometric model of this study is:

$$lnSDVT_{it} = \partial_{it} + \emptyset_{1,it} GRNF_{it} + \emptyset_{1,it} FINCL_{it} + \emptyset_{j,it} lnK_{it} + \varepsilon_{it} \quad (1)$$

In the equation, $lnSDVT_{it}It$ is for the natural logarithm of sustainable development, and it is the dependent variable in the model and a measure of country-level attainment of the 17 sustainability goals. $GRNF_{it}$ is for green finance expressed as green bond valuation to GDP. $FINCL_{it}$ is for financial inclusion and an index of 7 financial access indicators. lnK_{it} is a vector of all control variables in logarithms, identified to be the logarithm of foreign direct investments (lnFDI), the logarithm of population density (lnPOPD), and the logarithm of economic growth (lnGDPK).

3.3 Techniques of Model

The study relied on the panel fully modified ordinary least squares (FMOLS) and panel dynamic least squares (DOLS) and pooled mean group/panel autoregressive distributed lag (PMG-PARDL) techniques to estimate the long-run panel cointegrating relationship between sustainable development and green finance and financial inclusion as dependent variables, as well as a heterogeneous analysis with the panel quantile regression technique.

3.3.1 The panel PMG/ARDL

The panel ARDL is suited for data that are integrated at level, that is I (0), at first difference, that is I (1), or both I(0) and I(1) (Alam et al., 2025). The unique ability of the PMG-PARDL lies in the efficiency and consistency of addressing autocorrelation, endogeneity, and heterogeneity (Edet et al., 2024; Markjackson & Agada, 2024). Furthermore, the PMG-PARDL estimator works well with small data (Pesaran et al., 1999).

With the PMG-PARDL estimator, equation 1 can be restated as equations 2 and 3 for or the thus:

$$\Delta lnSDVT_t = \omega_i + \gamma_i lnSDVT_{i,t-1} + \Psi_1 GRNF_{i,t-1} + \Psi_2 FINCL_{i,t-1} + \Psi_3 lnK_{i,t-1} + \sum_{j=1}^{f} \beta_{ij} \Delta\, lnSDVT_{i,t-j} + \sum_{j=1}^{g} \beta_{1ij} \Delta\, GRFN_{i,t-j} + \sum_{j=1}^{h} \beta_{2ij} \Delta\, FINCL_{i,t-j} + \sum_{j=1}^{m} \beta_{3ij} \Delta\, lnK_{i,t-j} + \epsilon_{it} \quad (2)$$

$$\Delta lnSDVT_t = \vartheta_i + \sum_{j=1}^{f} \eta_{11} \Delta\, lnSDVT_{i,t-j} + \sum_{j=1}^{g} \eta_{12} \Delta\, GRNF_{i,t-j} + \sum_{j=1}^{h} \eta_{13} \Delta\, FINCL_{i,t-j} + \sum_{j=1}^{m} \eta_{14} \Delta\, lnK_{i,t-j} + \sigma_i ECT_{i,t-1} + \varepsilon_{1it} \quad (3)$$

Where i represents the country (1, 2, 3, …, 12), t is the period (2014-2023), and f, g, h, and m represent the optimum time lags. ω_i and ϑ_i is the country's specific effect, and ϵ_{it} and ε_{1it} refers to the error terms. As is traditional, most ARDL models, including the panel ARDL model, require determining the error correction model (ECM), which contains the error correction term (ECT). In equation 3, σ_i is the speed of adjustment and its statistical expectation less than unity, negative, and statistically significant.

3.3.2 Panel FMOLS and DOLS

Further, the use of panel Dynamic Ordinary Least Squares (DOLS) and Fully Modified Ordinary Least Squares (FMOLS) to estimate long-run panel cointegration relationships was derived from the failures of the OLS estimators to produce efficient and unbiased estimates, as well as the inherent endogeneity problem in them (Ozdemir & Kayhan, 2021). To address these issues, panel DOLS and panel FMOLS have emerged. While Philips and Hansen (1990) developed the FMOLS, Stock and Watson (1993) developed the DOLS technique, but they both work towards eliminating statistical problems inherent in the OLS method by considering samples that are small as well as the structural dynamics of the series (Ozdemir & Kayhan, 2021). It also solves serial correlation problems using the Generalized Least Squares (GLS) method. Equation (4) describes the model estimation based on the DOLS method. With the benefit of heterogeneous cointegration, Hamit-Haggar (2012) availed that the FMOLS technique is ideal for panel analysis. To use the FMOLS, explanatory variables that will be used on the FMOLS must be stationary as either I(0) or I(1) (Ozdemir & Kayhan, 2021). For a panel FMOLS estimator, the coefficient β of the model in equation 1 was specified by Pedroni (1996), Pedroni (2000), and Khan et al. (2019) to be:

$$\beta_{NT}^{*} - \beta = \left(\sum_{i=1}^{N} L_{22i}^{-2} \sum_{i=1}^{T} (\chi_{it} - \bar{\chi}_i)^2\right)^{-1} \sum_{i=1}^{N} L_{11i}^{-1} L_{22i}^{-1} \left(\sum_{i=1}^{T} (\chi_{it} - \bar{\chi}_i)\phi_{it}^{*} + T\hat{\gamma}_i^{*}\right) \quad (4)$$

Where, $\phi_{it}^{*} = \phi_{it} - \frac{\hat{L}_{21i}}{\hat{L}_{22i}} \Delta\chi_{it}$, $\hat{\gamma}_i^{*} = \hat{\Gamma}_{21i}\hat{\Omega}_{21i}^{0} - \frac{\hat{L}_{21i}}{\hat{L}_{22i}}\left(\hat{\Gamma}_{22i} - \hat{\Omega}_{22i}^{0}\right)$ and $\hat{L}_i$ was the lower triangulation of $\hat{\Omega}_i$. The derived panel FMOLS by Pedroni (1996) does not have a different asymptotic distribution from the Dynamic OLS (DOLS). So, we performed the FMOLS and DOLS estimations to prove the consistency of the result. the FMOLS method

3.3.3 The panel quantile regression test

Koenker (2004) modified the quantile regression. Quantile regression has the attributes of a heterogeneous conditional distribution and also takes care of outliers and misspecification errors (Anser et al., 2021). With its ability to reveal the heterogeneous effects of covariates across quantiles, it provides more appropriate and robust estimates than the mean regression. Not to forget that it is also very applicable to different data structures. Equation 5 is used to describe the model specification of the quantile regression.

$$y_t = x_t'\beta_q \tag{5}$$

where, β_q is the vector of unknown parameters related to the qth quantile of sustainable development. While the OLS minimizes $\Sigma_t e_t^2$, The median or 50th quantile of sustainable development minimizes. $\Sigma_t|e_t|$, making it the least absolute-deviation regression. By extension, the quantile regression minimizes. $\Sigma_t q|e_t| + \Sigma_t(1-q)|e_t|$, which is a sum that produces the asymmetric penalties $q|e_t|$, representing underprediction, and $(1-q)|e_t|$, representing over-prediction.

Notably, the estimator of the qth quantile of sustainable development, $\hat{\beta}_q$, minimizes over β_q, The objective function is expressed as:

$$Min_{b\epsilon R^k}\left[\Sigma_{t\epsilon(t:y_t\geq x_t'\beta)}q\left|y_t - x_t'\beta_q\right| + \Sigma_{t\epsilon(t:y_t<x_t'\beta)}(1-q)\left|y_t - x_t'\beta_q\right|\right] \tag{6}$$

where, 0<q<1, so that β_q, rather than β, Identifies the beta estimate related to the q quantile.

If a standard conditional quantile is specified to be:

$$Q_q(y_t|x_t) = x_t'\beta_q \tag{7}$$

Then, for the Kth regressor, the coefficient for the qth quantile is the marginal effect of sustainable development, expressed as:

$$\frac{\partial Q_p(y|x)}{\partial x_k} = \beta_{qk} \tag{8}$$

So, with respect to our study, interpreting β_{qk} will be as "the change in a specified qth quantile of sustainable development from a one unit change in either green finance or financial inclusion.

4. Results and analysis

Across all observations, sustainable development, SDVT, in Table 3 shows the highest average at 67.93. We find that, on average, green finance has a lower level than most other variables, with an average score of 1.43. a situation that signals a low development of the financial market segment. The financial inclusion measure FINCL stands at a moderate 0.86 in average figures. GDP per capita, at 8288.76, shows our average population earns substantially economically compared to other countries. The average population density per square kilometer in our sample is 197.76, which reveals a mid-level population density rate. In contrast, foreign direct investment stands at a lower mean of 2.41 compared to other measurements.

SDVT reaches an upper limit of 81.70 while showing new small ups. GRNF shows extreme changes in green finance activity, reaching a high level of 52.61 compared to other variables. Compared to other cases, only 2.27% of observations show exceptional financial inclusion. GDPK shows its largest amount at 22056.67, which shows major differences between regions or data points in income for each person living there. POPD shows a peak of 634.12 to represent areas with very large numbers of residents. When foreign businesses invest in our country, the number of times they do so peaks at 9.84. Sustainable Development maintains firm average levels of growth during its lowest-performing periods. GRNF reports zero at some point, and FINCL demonstrates severe financial

exclusion patterns in every situation when its value hits -2.46. GDPK has a minimum value far below its mean, indicating economic disparities or poverty within specific areas. POPD reveals that even some parts of the population live in thinly inhabited areas. During specific timeframes, foreign direct investment reached and stayed below zero. The Jarque-Bera test for sustainable development had a 0.49 and 0.78 probability, showing that its data follows a typical normal distribution curve. Similarly, per capita GDP appears to be normally distributed, since its JB statistic value (3.76) and probability (0.15) show it might follow that pattern. The other variables show very low chances of being normally distributed, mainly because they vary strongly in their data.

Table 3. Descriptive statistics

	SDVT	GRNF	FINCL	GDPK	POPD	FDI
Mean	67.93	1.43	0.86	8288.76	197.76	2.41
Median	68.25	0.04	0.85	9020.44	131.01	2.09
Max.	81.70	52.61	2.27	22056.67	634.12	9.84
Min.	53.50	0.00	-2.46	1553.88	23.94	-0.04
Std. Dev.	6.91	6.20	0.65	4727.56	185.85	1.76
JB stat.	0.49	9876.18	309.61	3.76	27.58	126.68
Prob.	0.78	0.00	0.00	0.15	0.00	0.00
Observations	120	120	120	120	120	120

Note: The table above represent Source: Authors' computation, 2025; SDVT represents the sustainable development score that ranges from 0 to 100; GRNF represents green finance, which is proxied by the percentage of green bonds to each country's gross domestic product; FINCL represents financial inclusion, which is the index of seven financial access indicators as listed in Table 3 above; GDPK is economic growth that is proxied with gross output per capita; POPD is population density while FDI is for foreign direct investment to GDP

The correlation data in Table 4 shows that sustainable development and green finance are marginally positively correlated, and this positive association is not statistically significant. The results indicate that green finance is not associated with sustainable growth that much, despite helping projects deliver environmentally sustainable results. Our data shows that green finance does not relate to sustainable development at significant levels in this analysis. Also, our findings show that SDVT and FINCL have a statistically significant moderate positive relationship. More opportunities for everyone to access financial services accompany stronger economic development. Financial inclusion helps people get better access to banking services and funds while giving them more chances to develop their businesses sustainably. These results show an inclusive financial system is key to achieving long-lasting, sustainable economic growth.

Table 4. Correlation Analysis

	SDVT	GRNF	FINCL	GDPK	POPD	FDI
SDVT	1					
GRNF	0.092	1				
FINCL	0.243***	0.251***	1			
GDPK	0.857***	0.110	0.215**	1		
POPD	0.294***	0.459***	0.001	0.362***	1	
FDI	0.547***	0.205**	0.007	0.489***	0.473***	1

Note: The table above presents the correlation analysis, which depicts the linear relationship between two variables at a time; in Table 4, indications such as ***, **, and * represent significance at 1%, 5%, and 10%, respectively

When compared, the correlation between financial inclusion and sustainable development is stronger and more significant than between green finance and sustainable development. In moving towards a sustainable future, greater financial access has a

broader and more obvious connection to sustainability in emerging economies than just focusing on green finance. With its ability to include more people and companies to access the funds they need, financial inclusion is associated with sustainable economic development. The findings show green finance produces less significant results for sustainable growth than financial inclusion in this research data.

Table 5. Panel cross-sectional dependence

	CD Test of OLS Estimator		
Test	Statistic	d.f.	Prob.
Breusch-Pagan LM	162.65***	66	0.000
Pesaran scaled LM	8.41***		0.000
Bias-corrected scaled LM	7.75***		0.000
Pesaran CD	4.80***		0.000

Note: This table reports the test of panel cross-sectional dependence, which explains whether the country data are dependent on each other. The table reports both the statistical values and their respective probabilities. The null hypothesis (H0) is that the panel series are not cross-sectionally dependent. Asterisks *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.

The analyses in Table 5 show evidence of cross-sectional dependence among the data units within the dataset. The four cross-sectional dependence tests generated statistical significance at a p-value of 0.000. Since the tests demonstrate cross-sectional dependence in every analysis, we reject the hypothesis of independent observations. We have clear evidence of cross-sectional dependence from the Breusch-Pagan LM test statistic (162.65) with 66 degrees of freedom (d.f.). Statistics of 8.41 and 7.75 from the Bias-corrected and Pesaran-scaled LM tests verify that the tested data exhibits interdependence. We confirmed cross-sectional dependence because these tests function correctly even when heteroskedasticity and autocorrelation exist. The Pesaran CD test result of 4.80 strengthens our understanding that the data show strong links between observations across the population. Based on these findings, the analysis requires techniques to handle these dependencies because it needs standardized error estimation or models considering panel data and dependencies.

Following the test for cross-sectional dependence, the study also conducted the slope heterogeneity test. This test is required to determine whether the slopes in individual emerging economies are different from one another. This concern is important in econometric analysis to decide on the appropriate application technique.

In Table 6, the two versions of the heterogeneous test, delta and adjusted delta, had their respective null hypotheses rejected for homogeneous slope coefficients. This is evident in the probability of both statistics being lower than the 1% level. These results show that the relationship between sustainable development, green finance, and financial inclusion in emerging economies differs across the sampled emerging economies. Further estimation techniques should consider heterogeneity, such as those accounting for mean and pooled mean groups.

Table 6. Heterogeneity Test Results

Statistic Type	Delta	p-value
Delta	3.329***	0.001
Adjusted Delta	6.078***	0.000

Note: Null hypothesis (H_0): slope coefficients are homogeneous; $p < 0.10$ (*), $p < 0.05$ (**), $p < 0.01$ (***).

The result of the panel unit root tests is contained in Table 7 and was obtained using two techniques: the cross-sectionally augmented IPS (CIPS), a second-generation panel unit test, and the Im, Pesaran, and Shin (IPS) test, a first-generation test. Based on the CIPS outcomes, green finance was stationary at levels similar to the IPS result. This makes it the only I(0) variable. By contrast, sustainable development, economic growth, population density, and foreign direct investments are convincingly stationary after first difference, making them I(1) variables. In contrast, the IPS test confirmed the stationarity of financial inclusion after first differencing. Given these mixed results of stationarity, the most suitable econometric technique would be panel ARDL/PMG and FMOLS.

Table 7. Panel stationarity tests

Variables	Levels		First difference		Order of Integration
	IPS	CIPS	IPS	CIPS	
lnsdvt	0.14	-0.89	-5.06***	-3.14***	I(1)
grnf	-2.27**	-3.23***			I(0)
fincl	-0.38	-1.06	-2.23***	-2.05	I(1)
lngdpk	0.06	-1.38	-5.28***	-2.53**	I(1)
lnpopd	0.64	-1.09	-2.43***	-2.48**	I(1)
Lnfdi	-1.82**	-1.47		-2.69***	I(1)

Note: This table reports the panel stationarity tests based on two alternative outputs: the IPS represents panel unit root tests assuming no cross-sectional dependence, and CIPS represents test outputs with cross-sectional dependence. The null hypothesis (H0) is that the panel series are not stationary. Asterisks *, **, and *** indicate significance at 10%, 5% and 1%, respectively.

To test if there is no cointegration in panel data, Table 8 presents the Westerlund test for some panels and all panels, and the Kao Residual test examines the long-run relationship between sustainable development and the green finance and financial development model. Based on these test results, the three test variants conclusively reject the null hypothesis of "no cointegration" and affirm the existence of a long-run or cointegrating relationship in the model. However, based on these overwhelmingly convincing test results, there is no chance of discarding the evidence to confirm an overall cointegration test. We conclude that there is evidence of an overall long-run relationship between variables.

Table 8. Panel cointegration tests

Test status	Statistic	p-value	Decision
Westerlund cointegration test: Some panels	5.23***	0.000	Cointegrated
Westerlund cointegration test: All panels	4.20***	0.000	Cointegrated
Kao Residual Cointegration Test	-3.70***	0.000	Cointegrated

Note: This table reports the panel cointegration tests. The study relied on two cointegration tests, including the Kao and Westerlund cointegration tests. The study used the two variants of the Westerlund cointegration tests for some and all panels. This is done to establish that the cointegration decisions are beyond a reasonable doubt. Null hypothesis (H_0): No cointegration. Asterisks *, **, and *** indicate significance at 10%, 5% and 1%, respectively.

The essence of the panel vector error correction model (PVECM) is to further validate the long-run relationship established earlier in Table 8. Results from Table 9 support a long-run relationship between sustainable development and green finance and financial inclusion, with the negative and significant value of the cointegrating equation (coefficient = -0.372; p = 0.001). The highly significant cointegration means that about 37.2% of the variations away from the above-stated long-run equilibrium relationship is adjusted back. Besides, the PVECM also produces the short-run dynamics of green finance, financial inclusion, economic growth, population density, and FDI. The lag of the endogenous variables showed two sets of results. While the lagged changes in sustainable

development and green finance showed insignificant adverse short-run effects on sustainable development in emerging economies, the other short-run effect from financial inclusion was significantly detrimental. This finding means that short-run increases in financial access without reallocating frameworks, like appropriate regulation, lead to resource misuse for other economic concerns. Analysis of exogenous variables includes a significant and detrimental short-run effect of population density and FDI. This implies that larger populations tend to put potential pressure on resources, while FDI flows to emerging economies may be dominated by extractive and environmentally unsustainable activities.

Table 9. Panel Vector Error Correction Model Estimates

Variable	Coeff.	Std. Error	t-stat.	p-value
ECT1	-0.372	0.105	-3.534	0.001***
D(LNSUDVT(-1))	3.749	3.304	1.135	0.257
D(GRNF(-1))	0.009	0.013	0.73	0.466
D(FINCL(-1))	-0.829	0.207	-4.01	0.000***
LNGDPK	0.313	0.033	9.452	0.000***
LNPOPD	-0.614	0.044	-13.983	0.000***
LNFDI	-0.488	0.093	-5.224	0.000***

Note: This table reports the panel error correction model, an estimation with an error correction term (ECT). The ECT confirms the earlier cointegration we established by taking up a negative coefficient that is less than one and statistically significant. Asterisks indicate significance at 10% (*), 5% (**), and 1% (***) levels.

In comparing the influences of green finance (grnf) and financial inclusion (fincl) on sustainable development (sdvt) across the three estimation methods, namely panel ARDL, panel FMOLS, and panel DOLS, some distinct features emerged in Table 10, highlighting both similarities and differences in how these models capture the long-term effects. The panel ARDL, FMOLS, and DOLS showed that green finance and financial inclusion support sustainable development in emerging economies. However, financial inclusion is more beneficial than green finance. Oanh (2024) almost literally supports this finding by establishing that financial inclusion outperforms and is more beneficial than green finance in countries with high and low levels of financial development. On the supportive role of green finance for sustainable development, Lin et al. (2023) shared a deep semblance to our findings by linking green finance to economic and social sustainability innovation. This revelation makes the relevance of green finance extend beyond environmental goals. While the findings of Mo et al. (2023), Addai et al. (2024), and Kwilinski et al. (2023) have also agreed with our findings, their results are sector and region-specific. These heterogeneous effects mean that the benefits of green finance cannot be said to be uniform, which is why financial inclusion may be more effective. There is literature on other reasons why green finance could be less beneficial than financial inclusion for sustainable development. For instance, Sahu and Khatri (2024) established the importance of green finance for sustainable development. However, they identified that a low level of investment is a significant hindrance to its effectiveness in developing and emerging economies. Further, Shi et al. (2024) added a governance dimension to the ineffectiveness of green finance to sustainable development in emerging economies by conditioning its effectiveness on corruption control. According to the study, corruption levels reduce the impact of green finance on sustainable development. Zhang (2024) found that the influence of green finance is also affected by access to credit. This suggests that green finance is more effective when access to finance is improved. The argument also links green finance to improved financial inclusion.

Table 10. Panel: Long-run and short-run estimates

	Panel ARDL	Panel FMOLS	Panel DOLS
		Long-run	
	Coefficient	Coefficient	Coefficient
GRNF	0.0005***	0.0108***	0.0005**
FINCL	0.0070***	0.3058***	0.0035**
LNGDPK	0.0280***	-0.2973***	0.0657***
LNPOPD	-0.0022	-0.7446***	0.3684***
LNFDI	0.5701**	-0.1303***	-0.0051**
		Short-run	
ECT	-0.9270***		
D(GRNF)	0.0077		
D(FINCL)	-0.0088		
D(LNGDPK)	-0.0185		
LNPOPD	-0.0022		
LNFDI	0.5701**		
C	0.421		
Observation	108	108	108
Cross-section	12	12	12
R-Squared		0.9115	0.9979

Note: This table reports empirical results from the panel ARDL and checks with the panel FMOLS and DOLS. Asterisks indicate significance at 10% (*), 5% (**), and 1% (***) levels.

On financial inclusion being more beneficial to sustainable development in emerging economies, some studies have argued that it is because the influence of financial inclusion is more multidimensional, bearing on economic opportunities, financial literacy, and rural transformation (Danladi et al., 2023; Robles et al., 2024; Machaca et al., 2024; Sadar & Batul, 2024; Abramova et al., 2021). To prove, Nantharath et al. (2023), Markjackson and Agada (2024), and Tidjani and Madouri (2024) have shown that financial inclusion has consistently improved sustainable living in emerging sub-Saharan Africa. These studies have argued that the benefits of financial inclusion on sustainable development endure over time. However, studies have also shown that the influence of financial inclusion is more conditional on some fundamentals. Gigauri et al. (2023) argued that the rule of law and remittances complement the role of financial inclusion, while Barkat et al. (2024) revealed that financial inclusion plays a reinforcing and reallocating function on remittances.

Despite the more beneficial impact of financial inclusion than green finance on sustainable development in emerging economies, the way to go is not to abandon green finance over inclusive finance. The finding of Chen (2023) supports a synergistic and not competitive relationship between green finance and financial inclusion. This was done by establishing that integrating financial inclusion and green finance with eco-innovation has substantially improved sustainable development. This is because neither of the financial components is mutually exclusive to sustainable development. Ozili (2023) proved this by arguing that the influence of financial inclusion is more favourable to the economic and social aspects of sustainability than the ecological part.

To validate this claim, Table 10's results show an Error Correction Term measure of -0.9270 with a 0.0052 p-value. A negative and significant ECT shows that both series follow a stable trend toward their long-term equilibrium. Because the ECT's p-value is lower than 0.05, we can verify that our model variables follow a long-run cointegrating relationship.

Considering the different quantiles of sustainable development, Table 11 revealed that financial inclusion is more supportive around the median, above which it becomes insignificant. This revelation calls for constant reform of the financial inclusion policies in

emerging economies. This finding implies that the continuous influence of financial inclusion is only relevant at some setting levels of sustainable development, given the present level of financial inclusion in emerging economies. Wang et al. (2022) agree that only medium or higher levels of financial inclusion are important to advance environmental sustainability. This is partially agreed to by Geng and He (2021), who argued in favour of the ability of digital financial inclusion to support sustainability in middle- and high-income countries, but in low-income countries. For sub-Saharan Africa, Nantharath et al. (2023) agree with our findings on the significance of financial inclusion to sustainable development but emphasize the need to sustain reforms in financial inclusion. The implications of all these findings are in reinforcing reforms and continuous review of financial inclusion policies to maximize the benefits of sustainable development in emerging economies.

Table 11. Panel Quantile Regression Estimates

Variable	5th Quantile	40th Quantile	50th Quantile	60th Quantile	95th Quantile
GRNF	0.0008	0.0004	0.0005	0.0006	-0.0013***
	(0.209)	(0.665)	(0.633)	(0.760)	(0.008)
FINCL	0.0028	0.0310***	0.0280***	0.0301***	0.0059
	(0.853)	(0.008)	(0.003)	(0.001)	(0.357)
LNGDPK	0.1533***	0.1021***	0.1072***	0.1100***	0.1214***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
LNPOPD	0.0260*	0.0201**	0.0160**	0.0138**	0.0101
	(0.076)	(0.014)	(0.020)	(0.044)	(0.170)
LNFDI	0.0176	0.0502***	0.0449***	0.0419***	0.0284***
	(0.189)	(0.000)	(0.000)	(0.000)	(0.002)
C	2.646***	3.150***	3.1452***	3.1405***	3.1445***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Pseudo R2	0.610	0.537	0.531	0.536	0.594
Adjusted R2	0.593	0.517	0.510	0.516	0.576
Prob (Quasi-LR stat)	0.000	0.000	0.000	0.000	0.000

Note: This table reports empirical results from panel quantile regression showing the distributional response of the dependent variable, which is sustainable development. Asterisks indicate significance at 10% (*), 5% (**), and 1% (***) levels.

The panel quantile regression output has produced insightful outcomes not revealed by the earlier panel ARDL, FMOLS, and DOLS. Our quantile regression analysis shows that green finance fails to significantly impact sustainable development consistently at the lower or middle parts of sustainable development in emerging economies, despite its positive but insignificant effects from the 5th through to the 60th quantiles. The early and central levels of sustainable development distribution remain unaffected by green finance practices. The relationship between green finance and sustainable development in emerging economies turns strongly negative at the 95th quantile ($p = 0.008$). Research shows that when sustainable development reaches its highest levels in emerging economies, higher green finance can harm that development. The data shows that green finance has limited significance on the sustainable development of emerging economies during low sustainable growth stages, but may turn counterproductive when growth reaches higher levels. The result showing that green finance was only significant and also detrimental at the 95th quantile could be attributed to the earlier submission of D'Orazio and Dirks (2022), who established that high-performing emerging economies are at risk of losing the benefit of green finance on sustainable development on account of reasons like transitional cost regulations.

On the contrary, financial inclusion has been seen to benefit lower and middle performers more than the extremes. This does not align with Oanh and Dinh (2024), who

established that digital financial inclusion impacts all quantiles and time frequencies in Vietnam. While it can be argued that the upper performers, as is the case with the 95th quantile, already have a broad financial access base, the lower performers are disadvantaged groups with structural barriers that limit the efforts of inclusive financial policies. Iddrisu et al. (2022) highlighted that structural barriers like low education, distance from financial institutions and associated services, quality of institutions, and population growth tend to overwhelm access to financial services that ultimately affect sustainable development. Demir et al. (2020) agree with our finding but with another argument favoring income as the main determinant of the favorable relationship between financial inclusion and sustainable development. Although their study was primarily about inequality, inequality is one of the most significant pillars of sustainable development in emerging economies. The core conclusion of our findings is that green finance is only significantly detrimental among the high-performing emerging countries. At the same time, financial inclusion is most effective in middle-performing emerging economies.

Also, GDP per capita demonstrates beneficial impacts throughout every level of representation in the analysis. As population density increases, it helps sustainable development, but to a lesser extent, while foreign direct investment drives greater sustainable development in the middle and upper portions of the distribution. The results show these impacts change depending on sustainable development levels, so we must study the entire data set instead of focusing only on the mean value. Foreign direct investment (FDI) shows powerful positive effects at the 40th, 50th, 60th, and 95th quantiles, proving highly significant through extremely low p-values between 0.000 and 0.002. FDI generates a positive effect at the fifth quantile level yet fails to achieve statistical significance with a p-value of 0.189. Foreign investment drives sustainable development effectively at mid and top performance levels and shows strong, consistent results as sustainable development continues to rise. FDI shows no major effect at the bottom end of the distribution quantile.

The model performs well because Pseudo R^2 values range from 0.531 to 0.609, while Adjusted R^2 measures fall between 0.510 and 0.593. Our model shows strong results by explaining most of the differences in sustainable growth rates at different data levels. The model demonstrates statistical reliability in all quantiles through its Prob (Quasi-LR stat) result of 0.000.

5. Conclusion and Policy Recommendations

The state of sustainable development in emerging economies has caused a lot of concern for their governments and scholars who find environmental and social challenges as indispensable elements in their economic progress. Following this, green finance has been proposed as a possible remedy to sustainable development challenges. However, due to the underdeveloped nature of the green finance market in emerging economies, our study has identified financial inclusion as a complementary medium to sustainable development in emerging economies. The study depends on twelve (12) emerging economies, including Brazil, Poland, Chile, South Africa, China, the Philippines, Colombia, Nigeria, India, Mexico, Mauritius, Indonesia, and Malaysia. Our study sample is from 2014 to 2023. This considers the estimation of long-run parameters with panel ARDL/PMG, FMOLS, and DOLS, with dynamic consideration using the quantile regression technique. The proxy for the financial inclusion data is the composite PCA index of seven indicators. The result of the error correction in the panel ARDL/PMG estimation was used to confirm the existence of a long-run relationship in the study model.

Further results from the long-run estimates of the panel ARDL, FMOLS, and DOLS showed that strong evidence of positive effects from both financial inclusion and green finance on sustainable development exists in emerging economies, with financial inclusion exerting the greater influence. The dynamic consideration with the quantile

regression technique showed that financial inclusion is more supportive of sustainable development for middle performers, while green finance was not significant for lower and middle performers but detrimental to high performers.

Although the study has helped fill the gap in knowledge about the comparative impact of green finance and financial inclusion on sustainable development in emerging economies by offering good insights to the reader, it is not devoid of limitations. First, secondary data from only twelve emerging economies might lack true representation, as these blocks of countries constitute the largest in the world. Also, the composite indices on financial inclusion only involve formal financial services; however, the inclusion of informal finance is excluded due to the unavailability of such data. Again, the 2014 to 2023 time period for twelve countries lacks the requirements for using some dynamic panel analytical tools like the system GMM, which is regrettably due to almost equal numbers of cross-sections and time periods. This kept giving outputs that omitted the lag of sustainable development. To tackle endogeneity, the study estimated the FMOLS with heterogeneous coefficients that are based on group weights. As more countries continue to use more green finance instruments, further studies should focus on dynamic panel analysis.

Despite the limitations, the study's dynamic analysis revealed some interesting insights into the finance-development literature by establishing that financial inclusion was more beneficial to sustainable development than green finance. This discovery is not surprising because of claims that green finance is still at its early stage of development in emerging economies, and so many of these countries may not have started appreciating the importance of green finance to sustainable development goals. Also, the discovery that green finance is detrimental to sustainable development among high-performing emerging economies calls for some interesting policy insight. To begin with, there is a high possibility that this group of countries may be experiencing diminishing returns from green investment or misallocation of green funds due to dwindling regulatory and institutional qualities. This means that there is the possibility that regulatory and institutional qualities will plateau as countries begin to make progress. The implication is that the use of green funds will begin to suffer from weak accountability and eventually lead to greenwashing. To curb this menace, a third-party audit framework must be involved while strengthening the institutions for green governance.

Based on the study findings, we recommended that emerging economies create more awareness on adopting green finance because of its potential to advance sustainable development. Policymakers also need to embed green finance into inclusive financial frameworks. This can be done by getting financial institutions to encourage the design of green financial products that can be accessed through digital and traditional channels of financial services. By so doing, small businesses and households can easily access green funding due to reduced barriers. Secondly, considering how financial inclusion was not consistently beneficial from the quantile regression, emerging economies are encouraged to adopt policies that are adaptive to specific development stages and needs. This calls for constant policy reviews that will monitor the effectiveness of inclusive financial services. Thirdly, having discovered that green finance is detrimental to high levels of sustainable development, there is a need for advanced emerging economies to implement stricter monitoring tools by way of utilizing third-party auditing frameworks. These tools, when integrated with effective institutional reforms, will help mitigate the adverse effects of green finance that are attributed to transactional costs or diminishing returns.

Author Contributions: Conceptualization, S.O.E.; methodology, S.O.E.; software, S.O.E.; validation, J.O.A.; formal analysis, S.O.E.; investigation, J.O.A.; resources, , S.O.E.; data curation, S.O.E.; writing—original draft preparation, , S.O.E.; writing—review and editing, J.O.A.; visualization, ; supervision, J.O.A.; funding acquisition, J.O.A.. All authors have read and agreed to the published version of the manuscript.

Funding: Authors have received no direct funding from any source.

Data Availability Statement: The main data sources for this study are from the World Bank databases, and the refined data will be available upon request. The World Bank data can be accessed online at: https://databank.worldbank.org/source/world-development-indicators.

Conflicts of Interest: The authors declare no conflict of interest.

AI Use Statement: The authors confirm that the idea and content of the manuscript are not AI-generated, nor did we use generative AI to generate our data and analysis. However, the authors acknowledge using Grammarly and ChatGPT to refine the coherence of ideas and grammar. Besides these, all the contents, model specifications, analysis, and interpretations were designed, executed, and verified by the authors through a painstaking academic exercise.

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