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Green Finance and Economic Growth: Empirical Evidence from Panel Data Using CCEMG and PCSE Methods*

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Abstract

This article constructs a comprehensive Green Finance Index (GFI) to explore the connection between sustainable finance and economic growth across 43 developed and developing countries, as classified by the International Monetary Fund (IMF), over the period 2013 to 2023. The GFI is developed based on three core dimensions—Finance, Environment, and Economy—using indicators such as green bonds, green loans, green investments, greenhouse gas emissions, forestry, and energy intensity of the economy. A min-max normalization method is employed to ensure comparability across countries and overtime. Using the Common Correlated Effects Mean Group (CCEMG) estimator as the primary methodology and the Panel-Corrected Standard Errors (PCSE) approach as a robustness check; the study investigates both the long-term and short-term dynamics of this relationship. The results reveal a clear contrast between short-run and long-run effects: while trade openness demonstrates a statistically significant and immediate impact on economic growth in the short run, green finance exerts its influence primarily over the long term. This suggests that sustainable financial investments contribute to economic development in a gradual and structural manner, highlighting the importance of long-term policy commitment and integration of green finance mechanisms into national and international economic strategies.

Keywords: Green Finance Index, Economic Growth, CCEMG.
JEL Codes: O44, C33, Q01

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1. Introduction

One of the most pressing topics in today's global discourse is ecology. The growing awareness of environmental degradation, climate change, and resource depletion has underscored the urgency of rethinking how societies interact with the planet. As a result, decision-makers, government institutions, and private sector representatives are aware of the importance of incorporating environmental priorities into all levels of decision-making. This realization has not only influenced environmental policy but has also reshaped economic and financial strategies. Therefore, this study contributes to literature in three major ways. First, it develops a composite Green Finance Index (GFI) that integrates financial, environmental, and economic dimensions, addressing the gap in existing research that often considers green finance through isolated indicators. Second, it draws on the endogenous growth theory (Romer, 1990) and ecological modernization (Mol & Spaargaren, 2007) to investigate how sustainable financial mechanisms influence economic growth in both the short and long term. These theoretical lenses suggest that environmental protection and innovation-driven finance are not contradictory to growth but are potential sources of sustained development. Third, by including 43 countries categorized by the IMF as developed and developing, the study enables a comparative perspective that reflects the heterogeneous capacities and institutional structures of countries in addressing green finance and its developmental impact. This country's selection is also motivated by the global nature of environmental challenges and the differentiated responsibilities enshrined in international climate agreements.

Since its establishment in 1992, the UN Framework Convention on Climate Change (UNFCCC) has gained almost universal membership, with 197 Parties. However, the agreement in question mainly functions as a regulatory framework and does not stipulate mandatory legal responsibilities for emission reductions. To address this limitation, the Kyoto Protocol was adopted in 1997 and came into effect in 2005 (Kyoto, 1997). The Protocol obligating developed economies to pursue a coordinated 5% reduction in greenhouse gas emissions during the 2008–2012 period, using 1990 as the baseline (Delbeke, 2019:40).

The international community has set a goal of limiting global warming to 2 °C. To this end, countries committed to creating an international climate agreement at the conclusion of the Conference of the Parties (COP21) to the UNFCCC in Paris in December 2015 (Iyer et al, 2015:10; Elzen, 2010:246). In 2015, the Paris Agreement surprised many by not stopping at limiting warming to "well below" 2 C, but included the text "to pursue efforts" to limit it to 1.5 C (UNFCC, 2015 and Dessens 2016:64). In this evolving context, green finance has emerged as a vital mechanism for aligning economic activities with environmental sustainability. According COP29 in Baku (held in 2024 November), nearly 200 countries reached a landmark agreement focused on climate finance, committing to triple annual funding for developing countries to USD 300 billion by 2035 and mobilize USD 1.3 trillion annually from public and private sources (UNFCC, 2024). Therefore, to achieve the Sustainable Development Goals, it is essential to launch a new agenda for green projects and significantly increase investment in environmentally beneficial initiatives. This can be accomplished through innovative financial tools and policies, including green bonds, green banks, carbon market mechanisms, fiscal reforms, green central banking, financial technologies, and community-based green funds (Sachs, 2019:3; Wen, 2021:5).

This paper explores the relationship between green finance and economic growth, aiming to determine whether environmental investment serves as a catalyst or constraint for GDP (Gross Domestic Product) performance. By integrating control variables such as inflation and trade openness, and considering country-level heterogeneity, the research provides empirical insight into the evolving relationship between sustainability-oriented finance and macroeconomic outcomes. This study is structured as follows: Section 2 presents a comprehensive literature review, organized thematically to highlight key debates and findings. Section 3 provides a detailed overview of the history of green finance, its connection to economic growth, and the construction of the Green Finance Index. Furthermore, it examines how this relationship has been addressed in existing literature. Section 4 outlines the data sources and methodological framework employed in the analysis. Section 5 discusses empirical results, while section 6 concludes the paper with a summary of the key findings and implications, offering a critical discussion and avenues for future research.

2. Literature Review

Many recent studies have examined the relationship between green finance and economic growth. The general view in the literature is that green finance plays an important role in supporting sustainable economic development. While some studies find a strong positive effect, others show that the impact may depend on country-specific factors such as financial development, technology, or policy frameworks. In some cases, green finance improves the quality and efficiency of growth, even if the speed of growth slows slightly. The studies summarized in Table 1 provide an overview of different findings, methods, and their relevance to this research.

Table 1. Selected Empirical Studies on the Relationship Between Green Finance and Economic Growth

Author(s) & Year	Study Focus	Methodology	Key Findings	Relevance to this study
Ngo et al. (2021)	The influence of green finance on economic growth: A COVID-19 pandemic effects	Autoregressive Distrubuted Lag (ARDL), Vietnam (1986-2019)	The results exposed that green finance along with all control variables have a positive association with economic growth.	Supports the long-run positive impact of green finance found in this study.
Tong et al. (2022)	Green finance and sustainable growth.	GMM estimation	There is a positive correlation between GDP and and green finance	Aligns with the long-run significance of green finance.
Yin & Xu (2022)	Green finance and economic growth.	Entopy and Evaluation Method, China (2008-2020)	The alignment between China's green finance and economic growth remains relatively weak; however, the coupling and coordination between the two are progressing in a positive and constructive direction.	Similar to this study's finding that green finance takes time to impact growth.
Xu et al. (2022)	Green finance in resource efficiency and economic Growth	Panel Vector Autoregressive (PVAR), 29 countries (2015-2021)	The key findings indicate that the issuance of green bonds and green economic growth within the industrial	Emphasizes sector-specific long-run impact, consistent with this study's structural findings.

			sector can significantly enhance the rate of green economic growth in agriculture.	
Ma et al. (2023).	Green finance and environmental sustainability on economic growth.	Quantile Regression Model and Pooled Mean Group (PMG) G20 countries (2010-2020).	This study suggests that green finance is a catalyst for inclusive and sustainable growth in developing economies.	Reinforces green finance's role in long-term, inclusive growth.
Ouyang et al. (2023).	Green finance, natural resources, and economic growth: theory analysis and empricial research.	Panel analysis difference and difference model (DID), China provinces (2014-2018).	The findings indicate that green finance policies can enhance the scope and quality of economic growth, although they may lead to a slower growth rate.	Somewhat contrasts with this study, which finds long-term growth-enhancing effects.
Huang (2025).	Green Bonds and ESG investments: catalyst for sustainable finance and green economic growth	Panel regression analysis. China, Brazil, Russia, Australia, Canada, Saudi Arabia, and South Africa (2002-2021).	The results show that different countries follow different paths toward sustainable development, and green bonds and ESG investments have varying effects depending on the country's specific context.	It supports the idea that the relationship between green finance and sustainable development is not uniform, and effects can vary based on time and context.

3. Theoretical framework

3.1. Concept of green finance

The concept of green finance is relatively recent, and as such, a universally accepted and precise definition remains absent in academic literature. According to Lidenberg (2014:1), this lack of clarity stems from two primary reasons. First, many publications avoid defining the term altogether; for example, Spratt and Griffith-Jones (2013:8) omit a formal definition. Second, among those that do attempt to define green finance, there is considerable variation in interpretation. In existing literature, green finance is often used interchangeably with green investments (Zadek & Flynn, 2014:5) and is frequently conflated with related concepts such as climate finance, sustainable finance, green loans, and green investment (Lazaro et al., 2023:3). Labatt and White (2003:65) provide one of the few comprehensive definitions, describing green (or environmental) finance as encompassing all market-based instruments aimed at enhancing environmental quality and managing environmental risks.

3.2. Historical background of green finance

In 1992, the United Nations Environment Program Finance Initiative (UNEP FI) was established through a collaboration between UNEP and a consortium of commercial banks with the aim of instilling environmental awareness within the banking sector. This initiative marked the inception of Green Finance, serving as a pioneering effort in integrating environmental concerns into financial practices. Over time, the initiative expanded its scope by involving a broader array of financial institutions such as investment and commercial banks, insurers, and fund managers in constructive dialogues regarding the alignment of environmental protection with sustainable economic development. Its objective is to incorporate environmental considerations into existing financial services and operations. Presently, approximately 190 financial institutions from over 40 countries have pledged their commitment to the UNEP FI statement. Signatories of this statement benefit from access to a network where they can glean insights into emerging trends and best practices for capitalizing on green opportunities for growth, while also contributing to the advancement of sustainable finance agendas within their respective contexts (UNEP FI, 2010, 2011). Industrial development aimed at promoting economic growth has led to numerous adverse effects, including significant social and environmental challenges (Glaeser, 2002:277). Green finance is increasingly recognized as an effective tool for mitigating economic externalities without hindering economic growth (Meo and Karim, 2022: 173).

3.3. Green finance affects economic growth

By channeling investments toward environmentally friendly projects—such as clean energy, carbon reduction, and sustainable land use—green finance offers a framework for fostering both ecological responsibility and long-term economic resilience. The question that naturally arises is whether green finance can simultaneously support economic growth, or whether prioritizing environmental goals comes at a cost to traditional development (OECD, 2017). Although green finance has strong roots in the private sector—through instruments such as green bonds, sustainable investment funds, and green lending—its growth and effectiveness remain highly dependent on public sector intervention (Della, 2011:25). Although many do not believe in the Green New Deal (Tieahara, 2018:45, Veelen, 2021:132), the importance of state control and monetary policy in this regard is undeniable (Harris, 2019:4; Dziwok, 2021:21; Galvin, 2020:4). (Tong et al, 2022:6) found out that there is a significant positive correlation between real GDP per capita, the share of value added of agriculture, forestry, animal husbandry and fisheries in GDP, and the green development of agriculture.

3.4. What does the Green Finance Index Represents?

An index, commonly known as a statistical index, serves as an essential tool for measuring and analyzing quantitative changes in social and economic variables. Depending on their measurement scope, indexes are categorized into individual indexes, which focus on a single aspect, and composite indexes, which aggregate multiple indicators into an overall measure (Wang, 2021:280).

The primary motivation for constructing a Green Finance Index lies in the ease of calculation, as well as in enhancing objectivity and comparability. Like widely used indices such as GDP, the Consumer Price Index (CPI), the NASDAQ-100, or the S&P 500, indices serve as valuable tools for aggregating complex information into a single, interpretable measure. Given that green finance encompasses a wide range of indicators, consolidating them into one comprehensive index allows for a more coherent and consistent analysis. (Iqbal et al., 2021:40), (Yang et al., 2021:5), (Xiaofei, 2022:987) they have given the wide-ranging nature of green finance, researchers have classified its components into key categories and developed a composite Green Finance Index. This index generally includes indicators such as renewable energy, green bonds, green investments, green loans, green securities, greenhouse gas emissions, forestry, sustainable land use, and carbon finance.

3.5. Construction of Green Finance Index

In this study, the Green Finance Index (GFI) is constructed based on three key segments: finance, environment, and economy. While the finance and economy dimensions are traditionally interrelated, the integration of the Environmental dimension reflects the increasing importance of sustainability within financial and economic systems. Within the finance segment, the primary indicators include green bonds, green loans, and green investments, which collectively represent the financial instruments and flows directed toward environmentally beneficial projects. The environmental segment incorporates indicators such as greenhouse gas (GHG) emissions, and forestry coverage, capturing the ecological footprint and transition efforts of each economy. Lastly, the economic segment includes energy intensity of the economy as a proxy for economic efficiency and sustainability, reflecting the degree to which economic output is decoupled from energy consumption.

4. Methodology and Data

This study investigates the impact of green finance on economic growth using panel data. The dependent variable is GDP, while the main independent variable is the GFI, which was constructed using the entropy method to reflect a composite measure of green finance across countries. Inflation and open tradeness are included as control variables. Prior to estimation, the dataset was subjected to several diagnostic tests. The Pesaran CD test and the Breusch-Pagan LM test confirmed the presence of cross-sectional dependence, and the slope heterogeneity test revealed significant structural differences across countries. Unit root tests indicated that all variables are stationary at first difference, except for inflation, which was found to be stationary at level. Given the presence of cross-sectional dependence and mixed stationarity, second-generation panel estimation techniques were employed. The Common Correlated Effects Mean Group (CCEMG) estimator was used to capture the long-run relationship, while the Panel-Corrected Standard Errors (PCSE) model was applied as a robustness check for short-run dynamics.

4.1.Entropy method

The concept of “entropy” originally emerged in thermodynamics and was employed to quantify the level of disorder or randomness within a system (Yin & Xu, 2022:2). The entropy method is based on the principle that indicators are assigned weights according to the amount of information they contain. Specifically, an indicator’s entropy is inversely related to the information it provides—meaning, the more informative an indicator is, the lower its entropy. Consequently, the weight assigned to each indicator increases proportionally with the amount of information it offers. In this study, the green finance index utilizes the entropy method to capture the relative development level of green finance by calculating the weights of various indicators that reflect changing trends within a particular region or area over a defined period (Yang et al., 2021:8). Steps of calculations green finance index via entropy method are given in Table 2.

Table 2. Steps of Calculations Green Finance Index Via Entropy Method

Steps	Equation	Description
Normalizing data.	$X_{ij}^{*} = \frac{Xij - min(Xj)}{\max(Xj) - min(Xj)}$ (1)	$X_{ij}^{*}$is the normalized value of the jth indicator
Calculating the Ratio of Each Indicator.	$Pij = \frac{X_{ij}^{*}}{\sum_{i=1}^{n} X_{ij}^{*}}$ (2)	n is total number of countries Pij is the proportion of each normalized indicator for country i
Calculating the entropy of each indicator.	$E_j = -\frac{1}{Ln(n)} \sum_{i=1}^{n} Pij \ln(Pij)$ (3)	E_j is the entropy value of indicator j.
Calculating the degree of diversification.	$d_j = 1 - E_j$ (4)	d_j is the degree of diversification for indicator j
Calculating the weights of each indicator.	$Wj = \frac{d_j}{\sum_{j=1}^{m} d_j}$ (5)	Wj is the weight assigned to the j th indicator m is the total number of indicators.
Calculation of the Green Finance Index.	$GFI = \sum_{j=1}^{m} Wj\, X_{ij}^{*}$ (6)	GFI is the Green Finance Index for country i

Note: The Green Finance Index (GFI) is constructed using the entropy method and consists of three main dimensions: Finance Dimension: Includes green bonds, green loans, and green investments, measured in monetary terms (USD). These represent financial flows directed toward environmentally beneficial projects and reflect the scale of green financial activity. Environmental Dimension: a) GHG emissions, measured in metric tons of CO_2 equivalent (tCO_2e), where lower values indicate better environmental performance; b) Forestry coverage, measured as the percentage of total land area covered by forests (%), with higher values reflecting stronger environmental preservation and ecosystem sustainability. Economic Dimension:Energy intensity, measured as kilograms of oil equivalent per $1,000 of GDP (constant prices). Lower values indicate higher energy efficiency and a more sustainable economic structure.

4.2. Sample selection

For this study, data from 43 countries spanning from 2013 to 2023 were selected from the sources provided in the accompanying Table 3. The dependent variable is Gross Domestic Product (GDP), while the independent variable is the Green Finance Index (GFI). Control variables, namely trade openness and inflation, were included due to their strong relationship with GDP, as they are key indicators that influence economic growth.

According to the descriptive statistics shown in Table 4, the average GDP across observations is approximately $1.59 trillion, with a high standard deviation of $3.59 trillion, indicating substantial variation among countries. GDP ranges from $22.9 billion to $22.1 trillion, reflecting both developing and developed economies in the sample. The mean GFI value is 0.065, with low variability (std. dev. ≈ 0.046). The index ranges from 0.016 to 0.843, suggesting that while most countries have relatively low GFI scores, a few have made significant progress in green finance. The average inflation rate is about 3.93%, but the high standard deviation (7.70) and extreme values (from -16.27% to 96.04%) indicate substantial differences in inflation stability, including cases of deflation and hyperinflation. The average trade openness is around 101.88% of GDP, with values ranging from 17.38% to 425.98%, showing varying degrees of trade integration, from relatively closed to highly open economies.

Table 3. Variables Description

Variable	Log form	Description	Sources
GDP	lnGDP	GDP value (constant USD 2015)	World Bank Development Indicator
Inflation	INF	Inflation, consumer prices (annual %)	World Bank Development Indicator
Trade openness	lnOTR	Share of GDP	World Bank Development Indicator
Green Finance Index	lnGFI	Composite index calculated using the entropy method (details in section).	World Bank Development Indicator, OECD, IMF, EDGAR, author calculation.

Source: Author`s calculation

4.3. Model Construction

The model was built to study the impact of green finance on economic growth.

$$GDP_{ijt} = a_0 + ß_1\mathrm{GFI}_{it} + ß_2\mathrm{INF}_{it} + ß_3\mathrm{OTR}_{it} + \mathcal{E}_{it} \quad (7)$$

Where GDP_{it} refers to the value of economic growth indicator j of country i in the t^{th} year, GFI_{it} denotes the level of green finance index of country i in the t^{th} year, INF_{it} denotes inflation of country i in the t^{th} year, and OTR_{it} represents trade openness intensity of country i in the t^{th} year. a_0 is a constant term $ß_1, ß_2, ß_3$ are coefficients of the independent variable and control variables, respectively. Ɛ is a random disturbance term.

Table 4. Descriptive Statistics

Variable	Obs	Mean	Std.dev.	Min	Max
GDP	430	1.59e+12	3.59e+12	2.29e+10	2.21e+13
GFI	430	0.0646674	0.0462242	0.0157312	0.8432561
INF	430	3.929935	7.703264	-16.26701	96.0362
OTR	430	101.8786	73.82547	17.37715	425.9759

Source: Author`s calculation

4.4. Study Area

This study consists of an annual time series data covering the period from 2013 to 2023 for 43 countries. According to the International Monetary Fund (IMF) classification the countries categorized into Advanced Economies (Developed) and Emerging Market and Developing Economies (EMDEs). Countries' names are shown on Table 5.

Table 5. Classification of Countries

Advanced Economies (Developed)		
Austria	Greece	Portugal
Belgium	Hong Kong	Singapore
Canada	Ireland	South Korea
Czechia	Italy	Spain
Denmark	Japan	Sweden
Estonia	Latvia	Switzerland
Finland	Lithuania	UK
France	Netherlands	US
Germany	Norway	
Developing and Emerging Market Countries (EMC)		
Azerbaijan	Macao (China) *(EMC)*	Russia *(EMC)*
Hungary *(EMC)*	Mainland China	Sri Lanka
India	Nepal	Thailand
Indonesia	Pakistan	Türkiye *(EMC)*
Kazakhstan	Philippines	UAE *(EMC)*
Malaysia	Poland *(EMC)*	

Source: The IMF classification is used as a basis, the table is compiled by the author.

5. Results

5.1. Multicollinearity Test

Multicollinearity test was assessed to ensure it does not pose a concern in the model. The highest Variance Inflation Factor (VIF) value is below 4, which is well below the commonly accepted threshold of (Yang, 2021:43). This indicates that multicollinearity is not an issue in this study (see Table 6).

Table 6. Variance inflated factor.

Variable	VIF	1/VIF
lnGFI	1.02	0.981512
INF	1.00	0.997201
lnOTR	1.02	0.980395
Mean VIF	1.01	

Source: Author`s calculation

5.2. Cross-Sectional Dependency Test

This study employs the tests proposed by (Pesaran et al., 2004:143) to detect cross-sectional dependence. Specifically, the Pesaran-scaled LM test and the Pesaran CD test are utilized, as they are well-suited for identifying cross-sectional dependence in panel data models. The Pesaran-scaled LM test extends the original approach by Breusch and Pagan (1980:245). These tests are particularly valuable in settings where the cross-sectional dimension (N) is large relative to the time dimension (T), as they do not rely on a predefined spatial weight matrix and are effective even in small samples (Pesaran, 2004:155). To empirically test for cross-sectional dependence, the Pesaran CD test and the Breusch-Pagan LM test were applied to each variable. The results, reported in Table 7, show that all test statistics are highly significant ($p < 0.01$), confirming the presence of cross-sectional dependence across all variables. This supports the use of second-generation panel estimation techniques.

Table 7. Cross Sectional Dependency Test

Indicators	**Pesaran CD**	**Breusch-Pagan LM**	***p*-value**
H0: No cross-section dependence (correlation)			
lnGDP	81.55406	7660.266	0.0000
GFI	95.11967	9145.599	0.0000
INF	43.49854	3407.522	0.0000
lnOTR	36.41246	3162.144	0.0000

Source: Author`s calculation

5.3. Slope Homogeneity

According to the homogeneity test results (Pesaran, 2008:51), the null hypothesis is rejected, revealing heterogeneity among the sample sectors. As a result, using heterogeneous panel estimation methods is appropriate for this study. Additionally, when cross-sectional dependence is present, it is crucial to implement robust estimation techniques that address both cross-sectional dependence and slope heterogeneity. To assess the stationarity and determine the integration order of the selected variables, the Pesaran CIPS panel unit root test is utilized.

Table 8. Slope Homogeneity Test

H0: slope coefficients are homogenous	
Delta	p-value
10.025	0.000
13.574 *(adj.)*	0.000

Source: Author`s calculation

5.4. Unit Root Test

The results of the cross-sectional dependence test guide the choice between first- and second-generation unit root tests. Based on our findings, the presence of cross-sectional dependence necessitates the use of second-generation unit root tests. Accordingly, this study employs the Pesaran CIPS panel unit root test (Pesaran, 2007:266), which is specifically designed to address cross-sectional dependence in panel data. Unlike traditional unit root tests, the CIPS test mitigates cross-sectional dependence asymptotically by incorporating cross-sectional averages. This is achieved through the Cross-sectionally Augmented Dickey-Fuller (CADF) regression. All variables except inflation are non-stationary in levels, stationary in first differences.

Table 9. Unit Root Test Results

Variables	CIPS (level)	CIPS (first level)	Result
lnGDP	-1.781	-2.264	I(1)
GFI	-1.427	-2.651	I(1)
INF	-2.617	--	I(0)
lnOTR	-1.784	-2.23	I(1)

Source: Author`s calculation

5.5. Cointegration

Traditional cointegration tests, such as those introduced by Pedroni (2001:101) and Kao (1999:15), do not consider cross-sectional dependence. Since the data in this study display cross-sectional dependence, using these tests could lead to biased and unreliable results. To address this issue, we employ the error correction-based panel cointegration test developed by Westerlund (2007:711), which explicitly accounts for cross-sectional dependence. Consequently, the Westerlund test is used in this study to investigate the long-run cointegration relationships among the variables.

Table 10. Westerlund Cointegration Test

H0: No cointegration Ha: Some panels are cointegrated		
	Statistic	p-value
Variance ratio	-3.1792	0.0007

Source: Author`s calculation

Since p value is $0.0007<0.05$, the null hypothesis is rejected. Therefore, there is evidence of cointegration between GDP, GFI, and OTR in at least some of the panels.

5.6. Panel Mean Group

After confirming existence of cointegration relationships, this study applies to CCEMG method. In addition, this method allows heterogeneity as well as considering cross-sectional dependence. (Pesaran, 2006:982) introduced two alternative estimators for calculating the average of individual slope coefficients in the presence of cross-sectional dependence: the Common Correlated Effects Mean Group (CCEMG) and the Common Correlated Effects Pooled (CCEP) estimators. Each cross-sectional unit i is estimated separately using the following regression.

$$y_{it} = \alpha_i + x'_{it} ß_i + \bar{y}_{t\Upsilon 1i} + \bar{x}'_{t\Upsilon 2i} + \mathcal{E}_{it} \quad (8)$$

Here is y_{it} is dependent variable, x'_{it} is vector of explanatory variables, $\bar{y}_t and\ \bar{x}_t$ cross-sectional averages of the dependent and explanatory variables, $ß_i$ is induvial slope coefficients, and α_i is induvial intercepts. The CCEMG estimator is calculated as the average of the individual slopes:

$$\widehat{\mathcal{B}}_{CCEMG} = \frac{1}{N}\sum_{i=1}^{N} \widehat{\mathcal{B}} \quad (9)$$

Table 11. Results of Common Correlated Effect Mean Group (Ccemg) Test

Variables	Coefficient	Standart error	Z (%)	P >│z│ (%)
Dependent variable lnGDP				
lnGFI	0.1131679	0.0578644	1.96	0.050
lnINF	-0.0016377	0.0050616	-0.32	0.746
lnOTR	0.2465684	0.0705256	3.50	0.000
_cons	28.6099	0.883263	32.39	0.000
Wald chi2 = 16.15 Prob>chi2 = 0.0011 Root Mean Squared Error (sigma) = 0.0069				

Source: Author`s calculation

According CCEMG test result in Table 11 Wald Chi² (3) = 16.15, p = 0.0011 overall model is statistically significant at the 1% level. A 1% increase in trade openness is associated with a 0.247% increase in GDP per capita, on average. This is statistically significant at the 1% level. A 1% increase in the Green Finance Index is associated with a 0.113% increase in GDP per capita. This is marginally significant at the 5% level. The inflation variable is statistically insignificant on GDP per capita.

5.7. Robustness check with Panel Corrected Standard Errors (PCSE) Technique.

In this study, the PCSE technique is applied as a robustness check to validate the consistency of the main estimation results. PCSE is particularly suitable for addressing issues commonly found in dynamic heterogeneous panel data, such as autocorrelation and cross-sectional dependence. It offers more reliable standard error estimates and is less influenced by outliers, making it a valuable tool for confirming the robustness of the findings derived from the primary CCEMG estimation (Bailey & Katz, 2011:3; Eboiyehi, 2017:44; Reed & Webb, 2010:56).

Table 12. Panel Corrected Standard Errors Test

Variables	Coefficient	Standart error	Z (%)	P >│z│ (%)
Dependent variable lnGDP				
lnGFI	-0.003818	0.0519167	-0.07	0.941
lnINF	0.000339	0.0003603	0.94	0.347
lnOTR	0.0012029	0.0004978	2.42	0.016
_cons	.0223386	0.0090147	2.48	0.013

Source: Author`s calculation

PCSE results in Table 12 show that short-run changes in green finance do not have a statistically significant impact on GDP growth. Trade openness with 0.016 p-value is statistically significant at 5%. A 1% increase in trade openness is associated with a 0.0012% increase in GDP growth in the short run. Inflation (0.347) does not show a significant short-run effect on GDP growth. Constant term is statistically significant.

6. Conclusion

The contrasting results between the CCEMG estimation and the PCSE model offer valuable insights into the structural and temporal behavior of green finance and trade openness. While CCEMG accounts for heterogeneity and unobserved common factors, capturing more stable long-term associations, the PCSE model serves as a robust check for contemporaneous relationships, providing short-term or immediate implications.

The relation between green finance on economic growth appears to be time-dependent. In the short-run (PCSE model), GFI shows an insignificant coefficient (–0.0038; $p = 0.941$), suggesting no immediate impact. However, in the long-run CCEMG model, GFI becomes statistically significant (0.1132; $p = 0.050$), indicating that the benefits of green finance materialize gradually. This supports the view that green investments require a longer horizon to affect growth through environmental improvements, structural change, and green innovation.

Inflation does not show a statistically significant impact on economic growth in either the short-run or the long-run. This may suggest that inflationary pressures during the sample period were either moderate or effectively managed, thereby exerting a minimal direct influence on growth. Alternatively, the effects of inflation may be indirect or contingent on other macroeconomic conditions not captured in the current model.

The effect of trade openness (OTR) on economic growth is positive and statistically significant across both short-run and long-run models. The short-run results (coef. = 0.0012; $p = 0.016$) suggest that openness to trade yields immediate benefits, while the long-run (coef. = 0.2466; $p < 0.001$) confirms a more substantial and sustained impact over time. The highlighted findings show that trade liberalization plays an important role in supporting both current and future economic performance.

In summary, the findings underscore the time-sensitive nature of green finance's impact on economic growth, with significant effects emerging only in the long run. This reinforces the notion that green investments yield economic returns through gradual processes such as environmental improvement, structural transformation, and innovation. Inflation appears to have a limited direct influence on growth, possibly due to effective macroeconomic management or indirect channels not captured in the model. Trade openness, however, consistently demonstrates a strong and positive role in promoting economic growth in both the short and long term. Overall, these results highlight the importance of sustained green finance policies and open trade frameworks in driving long-term economic development.

From a policy perspective, these results suggest that governments should adopt long-term green finance strategies and avoid relying solely on short-term outcomes. Policy tools such as tax incentives for green investments, the expansion of green bond markets, and integration of environmental risk assessments in financial regulation can help enhance the effectiveness of green finance. Moreover, fostering trade openness should remain a priority, particularly by promoting international green trade agreements, reducing tariff barriers for green technologies, and encouraging cross-border sustainable finance initiatives.

Competing Interests

The author declares that he has no competing interests.

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Ethical Statement

It is declared that scientific and ethical principles have been followed while carrying out and writing this study and that all the sources used have been properly cited.

Author's Contributions

This article was created as a result of the author's own efforts and reviews.

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