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Green Finance in BRICS-T Countries: The Role of Economic Growth, Trade, Natural Resources, and Education

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Abstract: Current research predominantly treats green finance as an independent policy instrument and fails to provide a comprehensive framework regarding the mechanisms through which structural macroeconomic indicators shape green financial development in emerging economies. Motivated by this problem, the present study examines green finance dynamics in BRICS-T countries over the 1990-2023 period based on economic growth, trade, natural resources, and education; it also includes population growth in the model as a control variable. Analyses conducted using econometric techniques (cross-sectional dependence tests, homogeneity tests, CIPS unit root tests, Westerlund-Durbin-Hausman cointegration analysis, CCE and AMG estimators, Dumitrescu-Hurlin causality tests, and Panel ARDL tests) reveal that economic growth reduces green finance in both the short and long term. Furthermore, in the long term, natural resources and population growth negatively affect green finance. On the other hand, trade and education positively support green finance, playing a critical role in the development of sustainable financial practices. Dumitrescu-Hurlin causality test results confirm unidirectional causality relationships running from green finance to natural resources, population growth, and education variables. In light of these findings, this study reveals the dynamics of green finance in emerging BRICS-T economies, offering policymakers an empirical framework for developing economic strategies aligned with environmental sustainability. Additionally, it emphasizes the necessity of aligning macroeconomic growth policies with sustainable financial development, promoting eco-friendly trade integration, and strategically utilizing educational investments to build green financial capacity.

Keywords: green finance; BRICS-T; economic growth; trade; natural resources; education.

JEL classification: C10; G20; F30.

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1. INTRODUCTION

Today, humanity faces some of the most significant challenges in many parts of the world, such as climate change, pollution, environmental degradation, biodiversity loss, water crisis, and humanitarian problems such as poverty, lack of employment, forced migration, hunger, lack of health infrastructure and education, and armed conflict in many parts of the world (Emmerij *et al.*, 2001; Güler *et al.*, 2025). The Global Risk Report has consistently identified climate change, biodiversity loss, and similar environmental problems as the most important risks at the global level (WEF, 2021). The financial sector plays a crucial role in enabling humanity to overcome such challenges. It is insufficient to develop the necessary technologies and policy frameworks to address these problems. The lack of financial resources to implement these solutions at the scale of priority action areas is a significant obstacle to managing these problems and achieving inclusive and sustainable growth for all, within planetary boundaries (Steffen *et al.*, 2015).

To lead climate action, sustainable development, and green recovery, the financial sector is developing strategies and innovative measures to ensure that sufficient capital is channeled to projects with social and environmental benefits, while simultaneously gradually shifting funds away from unsustainable projects and industries that have major negative impacts on the environment and humanity, particularly those that amplify the impacts of climate change. Green finance is an innovative concept that aligns with the financial sector's responsibility to meet today's mega challenges in a way that creates both job and social value without harming the environment (Thomson, 2021).

Green finance is probably most simply understood as a set of strategies and methods for obtaining, collecting, and allocating funds (both from the private and public sectors, as well as philanthropic contributions) to close the enormous investment gap in creating and sustaining a new, climate-resilient, sustainable, and environmentally sound environment. As UNEP (United Nations Environment Programme) has noted, this infrastructure also makes good business sense. It will help countries solve a multitude of societal problems, meet their climate action commitments and nationally determined contributions in line with the Paris Agreement, and achieve the 17 United Nations Sustainable Development Goals (UN SDGs) in the current decade from 2021 to 2030 (Volz, 2018; Nawaz *et al.*, 2021).

It is estimated that investments of several trillion dollars are needed each year to finance climate action and achieve the UN SDGs by 2030 (Barua, 2020). Another estimate is that between $300 and $500 billion per year will be needed to build climate-resilient infrastructure between 2030 and 2050 (Adhikari & Chalkasra, 2023). Article 9 of the Paris Agreement, 2015, requires developed countries to commit 100% to building climate-resilient infrastructure billions of dollars per year to finance climate action programs for developing countries by 2020 (UNFCCC, 2016), but so far, this has not happened as planned. These figures far exceed the current public revenues in a country or global cross-border financial flows through mechanisms such as foreign direct investment in developing countries. As discussed in the next section, green finance programmes attempt to fill this investment gap through a range of instruments spanning the entire capital market. Engagement with governments, the public, and the financial sector is crucial to all these initiatives. International Capital Markets Association (ICMA) has created a framework that maps each target under the SDGs to a specific aspect of the Green Bond Principles to ensure that investors in green finance instruments know where their finance is being directed (ICMA, 2019).

Green finance encompasses the full range of financial activities that fund projects aimed at solving environmental problems and sustainably supporting economic growth. As countries strive to balance economic development with environmental protection, green finance has become a critical and ever more important element of contemporary financial systems. The interaction among economic growth, natural resources, trade, and education significantly shapes the effectiveness and adoption of green finance initiatives; these factors determine not only the financial environment but also the opportunities that emerge for sustainable investments (Hu & Wang, 2023; Liang & Nasruddin, 2024; Nie *et al.*, 2024; Xiao & Tabish, 2025). In this context, the BRICS-T countries - Brazil, Russia, India, China, South Africa, and Türkiye - stand out as the largest emerging economies, each exhibiting different economic growth rates. The relationship between economic growth and environmental sustainability is multifaceted, producing both positive and negative effects. On one hand, growing economies can increase investments in eco-friendly technologies and more effectively implement environmental policies such as carbon taxes. On the other hand, growth can intensify pressure on natural resources, and fossil-fuel–dependent industrialization can raise greenhouse gas emissions (Asif *et al.*, 2024). Thus, in the context of green finance, economic growth is often described as a double-edged sword: it can supply the capital required for sustainable projects, but if mismanaged, it may exacerbate environmental degradation and undermine long-term sustainability goals. The literature shows that integrating green finance strategies into economic policy can enhance performance across various sectors, thereby significantly contributing to sustainable development objectives (Mohsin *et al.* 2023; Citil, 2024; Xia *et al.*, 2024). However, the green transition may stall because of structural challenges, most notably the reluctance of traditional industries to adopt clean technologies (Harrison, 2023). Natural resources play a critical role in green finance processes both as primary inputs for economic growth and as focal points for sustainable resource management. Resource availability directly influences foreign direct investment and economic expansion, indirectly affecting the financial foundations of green initiatives. Sustainable management of these resources is essential for preserving environmental integrity and ensuring the long-term stability of financial systems. This underscores the necessity of a holistic approach to resource management and financial strategy (Wu, 2022; Liang *et al.*, 2024; Xiao & Tabish, 2025). Trade emerges as a key factor in shaping green finance policies and improving access to green technologies. With the global embrace of sustainable development, incorporating environmental criteria into trade agreements has become a strategic step to support green finance initiatives. Trade openness directly affects countries' capacities to access sustainable technologies and funding sources, making it a decisive factor in developing robust green finance mechanisms (ITC, 2024; Wang, 2025; Xiao & Tabish, 2025). Beyond economic factors, education plays a pivotal role in supporting sustainable development and fostering environmental responsibility. Effective educational programs can raise awareness among individuals and communities about environmental protection and resource conservation, thereby enhancing the success of green finance practices (Liang *et al.*, 2024). Nonetheless, creating broad societal awareness of sustainability principles remains a significant challenge, as disparities in education levels and access directly influence participation rates in green finance initiatives across different regions (Carney, 2024).

The contribution of this study to literature lies in its provision of critical insights for policymakers in BRICS-T economies regarding the dynamic effects of economic growth, trade, natural resource use, and education on green finance. By elucidating how these

variables interact with green finance, it can guide the development of policies that promote sustainable financial practices. Utilizing data from 1990 to 2023, the analysis employs various panel data techniques to examine the roles of economic growth, trade, resource use, and education in shaping green finance activities across BRICS-T countries. Building on these relationships, the study offers policy recommendations to foster the development of green finance in emerging economies.

The remainder of the article is structured as follows: Section 2 reviews the relevant literature. Section 3 presents the research gap and the study's contributions to the literature. Section 4 details the dataset and the model. Section 5 presents the methodological framework. Section 6 provides the empirical findings, while Section 7 discusses these results. The final section concludes the study and offers policy recommendations.

2. LITERATURE REVIEW

This literature review presents a summary of the key findings in the literature on the determinants of green finance, focusing on economic growth, trade, natural resource management, and education.

Pioneering studies by Goldsmith (1969), McKinnon (1973), and Shaw (1973) brought the interaction between financial system development and economic growth to the forefront of economic literature. These theorists argue that the financial system facilitates the identification of investment opportunities, restricts resources channeled into liquid but unproductive assets, promotes the conversion of savings into investment, accelerates technological innovation processes, and improves risk-management capacity. Conversely, there have been criticisms that the impact of financial factors on economic growth has been overstated. Lucas (1988) contended that the role of financial factors in growth is overemphasized, while Robinson (1952) famously argued that “where enterprise leads, finance follows,” suggesting that economic growth shapes the financial system. From this perspective, growth triggers the emergence of new financial instruments and regulations through demand channels, and the financial system dynamically and automatically meets these demands. On a global scale, rising environmental concerns have prompted a reexamination of the relationship between economic growth and the financial system, particularly the impact of growth on green finance activities. Among the few studies in this area, Chen *et al.* (2024) examined 30 emerging economies and highlighted green finance’s decisive role in renewable energy investments, demonstrating how carbon markets and green bonds spur sustainable development. Elhassan (2025), evaluating G7 countries, found that economic growth increases the environmental footprint in the short term but that green finance can mitigate this effect over the long term. Similarly, Sajjad *et al.* (2024) showed that while growth directly raises carbon emissions, financial innovation and green investments play a critical role in attenuating this impact. Adebayo and Kartal (2023), in a U.S.-focused study, detected a negative short-term correlation between green bonds and industrial carbon emissions, which shifted to a positive relationship over the long run. Mohsin *et al.* (2023) emphasized green finance as a vital tool for reducing environmental risks and promoting sustainable economic growth, and Vardar *et al.* (2023) demonstrated that while growth in emerging economies increases the ecological footprint, green finance and renewable energy investments can moderate this effect. Shahzadi *et al.* (2023) also reported that although economic growth in G7 countries raises carbon emissions, energy efficiency measures and

green investments can balance this trend. Finally, Xiao and Tabish (2025) found that in G7 economies, natural resource use, growth, population, education, and trade all have significant positive effects on green finance, especially economic growth and population increases, which emerged as the strongest determinants. However, most of these studies focus heavily on advanced economies (e.g., G7) or treat green finance strictly as an independent variable mitigating the adverse effects of growth. There remains a critical gap in understanding whether the "scale effect" of rapid, carbon-intensive industrialization in emerging blocs like BRICS-T crowds out green finance when it is evaluated as a dependent variable. Addressing this theoretical contradiction, the following hypothesis was tested:

H1*: Economic growth makes a significant and positive contribution to the development of green finance in BRICS-T economies.*

There is a growing interest in literature in the impact of trade openness (or trade volume) on green finance. Empirical studies in this context show that trade can influence green finance activities both directly and indirectly. Oanh (2024) finds that trade openness positively affects sustainable development, and when assessed through the lenses of green finance and financial inclusion, it emerges as a strong component of sustainability. Similarly, Tariq *et al.* (2024), under the concept of "green trade openness," analyze trade's effects on eco-friendly growth, emphasizing that liberalizing trade promotes environmental innovation and low-carbon emissions, making it an effective policy tool for achieving green growth targets. Qing *et al.* (2024) demonstrate that trade openness increases both economic development and green energy consumption, thereby indirectly contributing to the expansion of green finance activities. Ashraf *et al.* (2024) examine how digital trade, and environmental technologies stimulate financial demand, finding that digital commerce boosts investments in renewable energy projects and eco-technologies, thus supporting the volume of green finance. Kim *et al.* (2014), in their study of OECD countries, highlight the importance of aligning production, consumption, and trade processes with environmental sustainability and argue for a redesign of green growth strategies. Consequently, the literature indicates that trade openness has a positive effect on green finance: increasing international trade raises demand for eco-friendly goods and services, which in turn fosters the development of financial instruments such as green bonds, loans, and investment funds. While existing literature robustly links trade openness to eco-friendly innovations, it frequently overlooks the methodological complexities of cross-sectional dependence in highly integrated regional markets. Evaluating the specific transmission of trade integration into green financial outcomes using advanced, second-generation panel techniques is therefore essential to validate these dynamics. Building on the consensus that trade acts as a structural facilitator, the following hypothesis was tested for the BRICS-T context:

H2*: Trade contributes significantly and positively to the development of green finance in BRICS-T economies.*

Literature reviews indicating that natural resource rents present both an opportunity (as investment capital) and a risk (resource depletion, ecological degradation) for green finance explain how this relationship manifests across different countries and regional samples. Liang

et al. (2024), using data from 2000–2019, find that natural resource rents positively affect green finance in emerging economies. Focusing on China, Yu (2024) employs an ARDL approach to show that resource rents directly increase carbon emissions, but that the introduction of green finance mechanisms (e.g., green bonds) can significantly mitigate this effect. Similarly, Sadiq *et al.* (2024) examine how fintech development influences climate quality via green finance and resource rents in China, finding that while fintech reduces carbon emissions, fluctuations in resource prices undermine the sustainability of green projects. In the United States, Raihan (2024) uses ARDL analysis on data from 1970–2021 to show that a 1% increase in resource rents raises financial development by 0.30% in the long run, suggesting that properly managed resource wealth can strengthen financial systems. Finally, Chi and Ping (2024) analyze the interactions among resource rents, green innovation, geopolitical risk, and environmental pollution in BRICS countries using GMM; they demonstrate that green innovation offsets the environmental impacts of resource rents and that combining economic growth with appropriate technology policies lays the groundwork for sustainable development. This literature reveals a deeply polarized debate between the "capital opportunity" and "resource curse" dynamics, highlighting that outcomes are heavily dependent on the institutional context of the sample. To resolve this ambiguity and determine whether natural resource exploitation structurally supports or hinders the capitalization of green finance in resource-dependent emerging markets, the following hypothesis was established:

H3*: Natural resource exploitation makes a significant and positive contribution to the development of green finance in BRICS-T economies.*

The literature examining the impact of educational activities on green finance deepens both theoretical and empirical dimensions of the topic and emphasizes the critical role of education in sustainable development. Lee *et al.* (2023), in their study of China, revealed that green finance has a direct effect on economic decarbonization and that human capital inputs - such as internet access, financial literacy levels, and higher education - amplify this effect. Žalėnienė and Pereira (2021), highlighting higher education's contributions to sustainability, argued that universities are key actors in disseminating the UN Sustainable Development Goals and transforming societal mindsets. They emphasize that environmental principles integrated into curricula shape students' individual habits and interactions with stakeholders, fueling long-term demand for green finance instruments. In studies focused on green bonds, Bhutta *et al.* (2022) showed that financial regulations and information-sharing are fundamental drivers of green bond growth; transparency- and quality-focused educational activities enhance issuers' ESG credibility, thereby mobilizing market demand. Chen and Xie (2023), examining G7 economies via panel data analysis, found that education expenditures positively affect renewable energy sector growth - making education investments a prerequisite for the effective allocation of public and private resources to green finance. Liang *et al.* (2024), in their analysis of the interaction between natural resource rents and education, supported the positive impact of education on green finance and advocated for education-driven green finance strategies in resource-rich countries. Finally, Lee *et al.* (2025), in their study of green digital finance in China, demonstrated that education promotes green finance both directly and through industrial transformation, and that this effect is reinforced by high-quality educational inputs, economic development, and trade openness. Although studies

consistently confirm education as a prerequisite for sustainable transitions, they predominantly assess its indirect effects on emissions rather than its direct capacity to mobilize green financial markets. To address this gap by directly testing the impact of educational expenditures on the volume of green finance, the following hypothesis was tested:

H4*: Education expenditures make a significant and positive contribution to the development of green finance in BRICS-T economies.*

A comprehensive evaluation of the existing literature reveals that the theoretical framework concerning the macroeconomic determinants of green finance is complex and confined to specific contexts. In the context of economic growth (H1), the literature is divided between the optimistic view that growth stimulates sustainable investments and the critical perspective that carbon-intensive industrialization crowds out green finance, particularly in developing countries. Regarding trade openness (H2), although there is a general consensus that trade supports eco-friendly innovations and green finance, the structural implications of this effect in dynamic emerging markets have not yet been fully clarified. Natural resource management (H3) constitutes one of the most polarized themes in the literature; the debate over whether resource rents present a capital opportunity for green transition or a resource curse that fuels traditional and polluting investments remains unresolved. On the other hand, although education (H4) is widely acknowledged as an indisputable prerequisite for sustainability, it has been examined predominantly through its indirect effects on emissions rather than its capacity to directly mobilize green financial markets. Conceptually, the prevailing literature predominantly positions green finance as an independent policy tool aimed at curbing environmental degradation. However, this fragmented approach falls short in explaining how economic growth, trade, natural resources, and education shape green finance as a structural dependent outcome in rapidly transforming economies like the BRICS-T. Consequently, there is a critical need for new evaluations that holistically address the interaction of these four fundamental macroeconomic dynamics governing the trajectory of green finance.

3. RESEARCH GAP AND CONTRIBUTIONS OF THE STUDY

Existing research predominantly treats green finance as an independent variable, analyzing its effects on environmental degradation (Nawaz *et al.*, 2021; Adebayo & Kartal, 2023; Lee *et al.*, 2023; Vardar *et al.*, 2023). The general literature on green finance lacks a comprehensive understanding of how macroeconomic indicators inherently drive or hinder green finance development within the sample of emerging economies. This study fills this fundamental gap by systematically evaluating green finance as a dependent variable shaped by economic growth, trade, natural resources, and education in the context of BRICS-T countries. It frames green finance not merely as a policy tool, but as a financial outcome driven by structural macroeconomic factors. Unlike previous studies focusing on developed country groups such as the G7 (Xiao & Tabish, 2025), it holistically examines these dynamics within the highly dynamic and resource-dependent BRICS-T bloc. Methodologically, the study overcomes the limitations of first-generation panel techniques by employing robust second-generation methodologies (CIPS, Westerlund-Durbin-Hausman, CCE, AMG, and Dumitrescu-Hurlin tests) alongside a Panel ARDL approach to provide resilient estimates

accounting for cross-sectional dependence and unobserved common factors. Comparatively, while studies on advanced economies such as the G7 show that economic growth and resource utilization positively stimulate green finance, this study reveals that in developing BRICS-T countries, the 'scale effect' of traditional, carbon-intensive industrialization crowds out green finance, leading to a negative relationship. This stark contrast highlights critical institutional differences between developed and emerging markets. Practically, this empirical framework demonstrates that expanding green finance in emerging markets requires targeted eco-friendly trade integration and strategic educational investments, rather than relying solely on economic growth. Furthermore, the unidirectional causality running from green finance to resource usage and education underscores the predictive power of green financial instruments for macroeconomic shifts, offering policymakers a practical roadmap to decouple resource rents from conventional investments.

4. DATA SET AND MODEL

The study employs data from 1990 to 2023 to examine the roles of economic growth, trade, natural resource use, and education expenditures in shaping green finance activities across the BRICS-T countries using various panel data techniques. This period encompasses a critical phase of global environmental and economic transformation: the 1990s saw the rise of sustainable development in international economic policy and landmark agreements such as the 1997 Kyoto Protocol; the 2000s witnessed the mainstreaming of green finance practices and low-carbon growth strategies, further reinforced by global initiatives like the 2015 Paris Agreement; and in recent years, heightened awareness of climate change, carbon-neutral policies, and incentives for green investments have underscored the importance of green finance - particularly for emerging economies such as those in BRICS-T. For these reasons, the 1990–2023 window represents an ideal timeframe for assessing the evolution and impact of green finance activities both theoretically and practically.

While the relationships mentioned above were being investigated, the model presented in Equation (1) was used. In this specification, green finance (GF) serves as the dependent variable, while economic growth (GDP), trade (TRD), natural resource use (NRP), and education expenditures (GEE) are included as independent variables. Population growth (PG) is incorporated as a control variable due to the large and dynamic population structures of the BRICS-T countries, which can directly influence the scale of economic activities and environmental sustainability pressures. By controlling population effects, the study aims to isolate and more accurately assess the true impacts of GDP, TRD, NRP, and GEE on GF.

$$GF_{it} = \alpha_{0it} + \alpha_{1it}NRP_{it} + \alpha_{2it}PG_{it} + \alpha_{3it}TRD_{it} + \alpha_{4it}GEE_{it} + \alpha_{5it}GDP_{it} + \varepsilon_{it} \quad (1)$$

In Equation (1), α_{0it} denotes the intercept term and ε_{it} the error term. Detailed information on the variables used in the study and their descriptive statistics are presented in Table 1.

Table 1. Variables and descriptive statistics

Variable	Definitions	Mean	Median	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
GF	Green Bond Issuances by Country	4.005	0.599	11.343	5.126	34.964	9578.05***

NRP	Natural resources depletion (% of GNI)	2.384	1.705	2.346	1.582	4.852	114.27***
PG	Population growth (annual %)	0.984	1.077	0.665	-0.309	2.539	5.04*
TRD	Trade (% of GDP)	42.568	45.045	14.379	0.387	4.394	21.65***
GEE	Government expenditure on education, total (% of GDP)	4.044	4.14	1.272	-0.450	2.932	6.91**
GDP	GDP growth (annual %)	4.118	4.725	4.657	-0.809	4.409	39.14***

Note: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. GDP, NRP, PG, TRD, and GEE variables were obtained from the World Bank databases; GF variable was sourced from the IMF database.

Table 1 shows that the GF variable has the highest standard deviation, indicating pronounced differences across countries. In contrast, PG and GEE exhibit lower standard deviations and therefore more stable profiles. In terms of skewness, GF and NRP both display positive skewness, meaning their distributions are right-tailed and sensitive to high values. PG and GEE, on the other hand, exhibit negative skewness, indicating a concentration at lower values. TRD and GDP have relatively mild skewness, with distributions closer to symmetry. Looking at kurtosis, GF has a notably high kurtosis coefficient, reflecting a peak distribution. NRP, TRD, and GDP also show elevated kurtosis, indicating sensitivity to outliers, whereas PG and GEE have a flatter distribution. Finally, the Jarque–Bera test results indicate that none of the variables in the model follow a normal distribution.

5. METHODOLOGY

The econometric strategy of this study is specifically tailored to the structural characteristics of the BRICS-T panel dataset, where the time dimension (T = 34, from 1990 to 2023) is significantly larger than the cross-sectional dimension (N = 6). In such macro-panels, countries are highly interconnected through global trade, financial flows, and mutual environmental agreements, making cross-sectional dependence (CSD) highly probable. Ignoring CSD and country-specific slope heterogeneity in this context would lead to biased, inconsistent, and spurious estimates. Therefore, the methodological framework strictly follows a sequential diagnostic and estimation procedure to ensure robust findings. First, essential diagnostic tests are conducted to determine the appropriate econometric path. Given the dataset's structure (T > N), the Breusch-Pagan (1980) LM test is selected as the most appropriate and powerful diagnostic tool for CSD. Concurrently, the Adjusted Delta test (Pesaran & Yamagata, 2008) is applied to verify slope heterogeneity, which is crucial for small samples. The outcomes of these initial diagnostics dictate the selection of all subsequent econometric techniques. Because the presence of CSD and heterogeneity renders first-generation tests invalid, this study explicitly adopts second-generation methodologies. To analyze stationarity under these specific conditions, the Cross-sectionally Augmented Dickey-Fuller (CADF) and the Cross-sectionally Augmented IPS (CIPS) unit root tests are employed, as they successfully incorporate unobserved common factors to account for heterogeneity across series. This method is implemented by taking first differences in the ADF regression to remove cross-unit correlations, and its fundamental equation is as follows (Pesaran, 2006):

$$y_it = (1 - \phi_i)\, \mu_i + \phi_i\, y_(i, t-1) + u_it \quad (2)$$

In Equation (2), $i = 1, \dots, N;\ t = 1, \dots, T$ and $u_{it} = \gamma_i f_t + \varepsilon_{it}$. f_t is the unobserved common effects and ε_{it} is the error term. When $\phi_i = 1$, the equation analysed in the CADF test is as follows:

$$\Delta y_{it} = \alpha_i + \beta_i y_{i,t-1} + \varepsilon_{it} \tag{3}$$

In Equation (3), $\alpha_i = (1 - \phi_i)\mu_i, \beta_i = -(1 - \phi_i)$ and $\Delta y_{it} = y_{it} - y_{it-1}$. This extended regression equation is obtained by adding lagged first differences of y_{it}.

Since evaluating the stationarity of each cross-sectional unit individually with the CADF test can be cumbersome, the overall panel assessment is conducted using the Cross-sectionally Augmented IPS (Im, Pesaran, and Shin) test (CIPS) after estimating the CADF regressions. The CIPS statistic is defined as the average of the CADF statistics obtained for each cross-section (Pesaran, 2006).

$$CIPS = N^{-1} \sum_{i=1}^{N} CADF_i \tag{4}$$

After the stationarity analysis, a cointegration test is applied to determine whether a long-run relationship exists among the variables. If cross-sectional dependence is present and the model exhibits heterogeneity, the Westerlund (2008) cointegration test is considered an appropriate method.

The Westerlund–Durbin–Hausman panel cointegration test, developed by Westerlund (2008), is used to identify long-run relationships among variables. Applicable in the presence of cross-sectional dependence, this test requires the dependent variable to be stationary in first differences and the independent variables to be stationary either in first differences or levels. By allowing the autoregressive parameter to vary across cross-sections, the test evaluates the existence of cointegration both at the group level and for the panel. Consequently, it determines whether a long-run relationship holds for some cross-sections or across the entire panel (Westerlund, 2008; Di Iorio & Fachin, 2008). The test model is specified by the following equation (Westerlund, 2008):

$$\begin{aligned} y_{it} &= \alpha_i + \beta_i x_{it} + z_{it} \\ x_{it} &= \delta x_{it-1} + w_{it} \end{aligned} \tag{5}$$

It is assumed that the distribution of z_{it} in Equation (5) is consistent with the following system of equations - used to account for common factors and enable cross-sectional dependence.

$$\begin{aligned} z_{it} &= \lambda_i' F_t + e_{it} \\ F_{jt} &= p_j F_{jt-1} + u_{jt} \\ e_{it} &= \phi_i e_{it-1} + v_{it} \qquad (p_j < 1 \ for \ each \ j) \end{aligned} \tag{6}$$

$F_t;\ F_{jt}$ k-dimensional common factor vector,

λ_i; harmonized vector of factor loadings.

The kernel estimator required for the Westerlund-Durbin-Hausman test is expressed by Equation (7) below (Westerlund, 2008):

$$\widehat{w}_i = \frac{1}{T-1}\sum_{j=M_i}^{M_i}\left(1-\frac{j}{M_i+1}\right)\sum_{t=j+1}^{T}\hat{v}_{it}\hat{v}_{it-j} \tag{7}$$

$\hat{v}_{it}$ = OLS residuals, M_i = bandwidth parameter, the value of $\widehat{w}_i^2$ is consistent with the estimate of the long-run variance w_i^2 of $\hat{v}_{it}$. Here, the simultaneous variance estimate can be expressed by $\hat{\sigma}_i^2$. With these estimates, it is possible to write two different variance ratios as $\hat{S}_i = \widehat{w}_i^2/\hat{\sigma}_i^4$ and $\hat{S}_i = \widehat{w}_i^2/(\hat{\sigma}_i^2)^2$.

$$\widehat{w}_n^2 = \frac{1}{n}\sum_{i=1}^{n}\widehat{w}_i^2 \text{ ve } \hat{\sigma}_n^2 = \frac{1}{n}\sum_{i=1}^{n}\hat{\sigma}_i^2 \tag{8}$$

After all these calculations, Durbin-Hausman group and panel (DH_g, DH_p) statistics are estimated with the following equations (Westerlund, 2008):

$$\begin{aligned} DH_g &= \sum_{i=1}^{n}\hat{S}_i\left(\tilde{\phi}_i-\hat{\phi}_i\right)^2\sum_{t=2}^{T}\hat{e}_{it-1}^2 \\ DH_p &= \hat{S}_n\left(\tilde{\phi}-\hat{\phi}\right)^2\sum_{i=1}^{n}\sum_{t=2}^{T}\hat{e}_{it-1}^2 \end{aligned} \tag{9}$$

In the presence of cross-sectional dependence and model heterogeneity, the Common Correlated Effects (CCE) and Augmented Mean Group (AMG) estimators are considered appropriate methods for estimating long-run coefficients.

Pesaran (2006) expresses the CCE estimator in the form given by Equation (10) as follows:

$$y_{it} = \alpha_i d_t + \beta_{ki}x_{kit} + u_{it},\ u_{it} = \gamma_{im}f_{tm} + \varepsilon_{it} \qquad 10$$

By extending the model in Equation (10), the estimation equation presented in Equation (11) was formulated for each cross-section:

$$y_{it} = \alpha_i d_t + \beta_{ki}x_{kit} + \theta_{1i}\bar{y}_t + \theta_{2i}\bar{x}_{kt} + u_{it} \qquad 11$$

This structure integrates heterogeneity and common shocks into the model by considering common factor dependence across cross-sections. Pesaran (2006) assumes a random process of the form $\beta_i = \beta + v_i$ under heterogeneity for each slope parameter and extends it across cross-sections of dependent and explanatory variables to obtain this equation, which is an m-dimensional vector of the form $f_t = (f_{1t}, f_{2t},, \dots, f_{mt},)'$ in place of unobservable common factors. $\gamma_t = (\gamma_{i1}, \gamma_{i2},, \dots, \gamma_{im})'$ is the corresponding mx1 factor loading vector. The average effect is calculated as follows (Pesaran, 2006):

$$\hat{\beta}_{CCE} = N^{-1}\sum_i^N\hat{\beta}_i \qquad 12$$

These coefficients are obtained by dividing by N and taking the arithmetic mean.

The model for the AMG estimator proposed by Eberhardt and Teal (2010) is given by Equation (13):

$$\begin{gathered} y_{it} = \beta_i' x_{it} + u_{it} \text{ ve } u_{it} = \alpha_i + \lambda_i' f_t + \varepsilon_{it} \\ x_{mit} = \pi_{mi} + \delta_{mi}' g_{mt} + \rho_{1mi} f_{1mt} + \cdots + \rho_{nmi} f_{nmt} + v_{mit} \\ m = 1, \ldots, k \;\; f_{.mt} \subset f_t \\ f_t = \varrho' f_{t-1} + \epsilon_t \quad g_t = \kappa' g_{t-1} + \epsilon_t \end{gathered} \tag{13}$$

Where x_{it} is the vector of independent variables, a_i is the group-specific fixed effects, λ_i is the country-specific factor loading and f_t is the common factor set.

AMG estimator accounts for cross-sectional dependence via common dynamic effects. It is implemented in two stages. First, the dummy-variable–augmented first-difference equation is estimated by ordinary least squares:

$$\Delta y_{it} = b' \Delta x_{it} + \sum_{t=2}^{T} c_t \Delta D_t + e_{it} \tag{14}$$

Then, the regressions of the variable $\hat{\mu}_t$ on N standard units are estimated using the following equation:

$$y_{it} = a_i + b_i' x_{it} + c_i t + d_i \hat{\mu}_t^{\bullet} + e_{it} \tag{15}$$

$$\hat{b}_{AMG} = N^{-1} \sum_i \hat{b}_i \tag{16}$$

The study also seeks to investigate the presence of causality among the variables. In panel data analysis, when cross-sectional dependence is present, the Dumitrescu–Hurlin causality test is employed. The Dumitrescu and Hurlin test examine Granger causality while accounting for both heterogeneous causal relationships and heterogeneity in the regression model used (Dumitrescu & Hurlin, 2012).

The causality test model with stationary Y and X variables is as follows (Dumitrescu and Hurlin, 2012):

$$Y_{i,t} = \alpha_i + \sum_{k=1}^{k} Y_i^{(k)} Y_{i,t-k} + \sum_{k=1}^{k} \beta_i^{(k)} X_{i,t-k} + e_{i,t} \tag{17}$$

Equation (17) is used to test whether variable X has a causal effect on variable Y. To evaluate the main hypothesis, the simple average of the individual Wald statistics is considered (Dumitrescu & Hurlin, 2012).

$$W_{N,T}^{Hnc} = \frac{1}{N} \sum_{i=1}^{N} W_{i,T} \tag{18}$$

In equation (18), $W_{i,T}$ is the Wald statistic used to test Granger causality for country i. For $N, T \to \infty$ the mean statistic $Z_{N,T}^{Hnc}$ is evaluated where the asymptotic distribution holds (Dumitrescu & Hurlin, 2012):

$$Z_{N,T}^{Hnc} = \sqrt{\frac{N}{2K}}\left(W_{N,T}^{Hnc} - K\right) \quad 19$$

When T is constant and N>T, the mean statistic $Z_{N,T}^{Hnc}$ with a semi-asymptotic distribution is used (Dumitrescu & Hurlin, 2012):

$$Z_{N,T}^{Hnc} = \frac{\sqrt{N}\left[W_{N,T}^{Hnc} - N^{-1}\sum_{i=1}^{N} E\left(W_{i,T}\right)\right]}{\sqrt{N^{1}}\sum_{i=1}^{N} Var\left(W_{i,T}\right)} \quad 20$$

The test statistics, constructed using the estimated mean and variance values of this distribution, is presented in the form shown in Equation (21) (Dumitrescu & Hurlin, 2012).

$$Z_{N,T}^{Hnc} = \frac{\sqrt{N}\left[W_{N,T}^{Hnc} - N^{-1}\sum_{i=1}^{N} K_i\, x\frac{T_i-2K_i-1}{T_i-2K_i-3}\right]}{\sqrt{N^{-1}\sum_{i=1}^{N} 2K_i x\frac{(T_i-2K_i-1)^2 x(T_i-K_i-3)}{(T_i-2K_i-3)^2 x(T_i-2K_i-5)}}} \quad 21$$

As part of the robustness analysis, the Panel ARDL (Autoregressive Distributed Lag) model developed by Pesaran *et al.* (1999) is employed in this study. This method allows for testing the cointegration relationship among variables that are either I(0) or I(1), eliminating the requirement that all series be stationary at the same order. The Panel ARDL approach is widely preferred because it can estimate both short- and long-term relationships and provides reliable results even in small samples (Narayan & Narayan, 2004; Vieira & Da Silva, 2022). Based on the ARDL model, Pesaran *et al.* (1999) developed two different estimators: Mean Group (MG) and Pooled Mean Group (PMG). While the MG estimator imposes no restrictions and allows model parameters to vary across units, its main drawback is that it assumes long-term coefficients differ for each cross-section unit. In contrast, the PMG estimator constrains long-term coefficients to be the same across all units but allows interceptions, error variances, and short-term coefficients to differ. Particularly in heterogeneous models with cross-sectional dependence, the PMG method provides more reliable estimates of the short- and long-term effects of the independent variables. Accordingly, the PMG estimator based on the Panel ARDL approach is employed as a rigorous robustness check in this study. While the primary CCE and AMG estimators excel at accounting for unobserved common factors and cross-sectional dependence, applying the PMG-ARDL model provides a complementary validation by estimating dynamic short-term heterogeneous dynamics while constraining long-term coefficients to be identical across the BRICS-T panel. Obtaining consistent long-term signs and significance levels across these fundamentally different methodological approaches confirms the robustness and reliability of the primary findings.

6. RESULTS

In this study, the findings obtained with the Breusch-Pagan (1980) LM test are evaluated for the BRICS-T countries since the sample is (T>N). For the homogeneity test, the Delta test (Slope Homogeneity Test) developed by Pesaran and Yagamata (2008) was applied. Delta (Δ) test is used for large samples and Adjusted Delta (Δ_{adj}) test is used for small samples.

Since this study uses annual data from 1990 to 2023, it is more appropriate to use the Adjusted Delta (Δ_{adj}) test to test homogeneity. The results of horizontal cross-section dependence and Delta tests are given in Table 2.

Table 2. Cross-sectional dependence and homogeneity test results

Variable	Statistical Value	Probability Value
GF	19.053	0.000***
NRP	187.011	0.000***
PG	165.819	0.000***
TRD	149.736	0.000***
GEE	106.157	0.000***
GDP	78.163	0.000***
Δ	9.669	0.000***
Δ_{adj}	10.75	0.000***

Note: *** indicates 1% significance level.

The results presented in Table 2 indicate the presence of cross-sectional dependence among the variables and within the model. The findings suggest that the variables influence each other over time, underscoring the necessity of accounting for cross-sectional dependence. According to the results of the delta test, the variables exhibit a heterogeneous structure. Therefore, the analysis proceeded with the CIPS unit root tests, which account for cross-sectional dependence. The results of the CIPS unit root test are reported in Table 3.

Table 3. CIPS unit root test results

Variable	I(0)	I(1)
GF	-1.800	-6.503***
NRP	-0.646	-8.878***
PG	-0.990	-8.765***
TRD	-0.458	-6.480***
GEE	-0.194	-6.260***
GDP	-1.081	-6.987***

Note: *** indicates 1% significance level. Related critical values can be found in Pesaran (2006).

According to the CIPS test results presented in Table 3, all variables were found to be stationary at the first difference. Following the unit root analysis, the long-term relationship among the variables was examined using the Westerlund-Durbin-Hausman cointegration test. The results obtained are presented in Table 4.

Table 4. Westerlund-Durbin-Hausman cointegration analysis results

	Test Statistic Value	Probability Value
Durbin-H Group Statistic	11.949	0.000***
Durbin-H Panel Statistic	8.165	0.000***

Note: *** indicates 1% significance level.

According to the findings in Table 4, there is evidence of a cointegration relationship among the variables, indicating that they tend to move together in the long run. The long-run coefficients were estimated using the CCE and AMG estimators, and the results are presented in Table 5.

Table 5. Long-run coefficient estimation results

Estimator	Dependent Variable: GF	Coefficient	Std. Error	Z-Statistic	Probability Value
CCE	NRP	-0.164	1.252	-7.310	0.000***
	PG	-0.947	6.341	-5.100	0.000***
	TRD	0.638	0.209	-10.180	0.000***
	GEE	0.051	1.345	-10.040	0.000***
	GDP	-0.029	0.520	-7.920	0.000***
AMG	NRP	-0.145	0.654	-10.53	0.000***
	PG	-0.982	0.814	-11.21	0.000***
	TRD	0.715	0.14	-10.82	0.000***
	GEE	0.108	0.352	-7.31	0.000***
	GDP	-0.037	0.141	-10.97	0.000***

Note: *** indicates 1% significance level.

According to the results in Table 5, a one-unit increase in the NRP variable reduces the GF variable by -0.164 units according to the CCE estimate and -0.145 units according to the AMG estimate. Similarly, a one-unit increase in the PG variable decreases the GF variable by -0.947 units and -0.982 units, respectively. A one-unit increase in the TRD variable increases the GF variable by 0.638 units according to the CCE estimate and 0.715 units according to the AMG estimate. For the GEE variable, this effect is 0.051 and 0.108 units, respectively, while a one-unit increase in the GDP variable reduces the GF variable by -0.029 units according to the CCE estimate and -0.037 units according to the AMG estimate. In other words, the long-term forecasts show that increases in natural resource usage and economic growth weakly reduce green finance activities, while population growth strongly decreases it. On the other hand, increases in trade activities lead to an increase in green finance activities, while the effect of increases in education expenditures on green finance is limited and positive.

In the next phase of the study, the causality relationships between green finance and the independent variables were examined. The results of the Dumitrescu-Hurlin Causality test analysis are presented in Table 6.

Table 6. Dumitrescu-Hurlin causality test results

Null Hypothesis	W-bar Test Statistic	Z-bar Test Statistic	Probability Value
GF↛NRP	-25.144	-10.321	0.029**
NRP↛GF	14.273	3.044	0.356
GF↛PG	-19.631	-10.138	0.017**
PG↛GF	14.323	3.073	0.381
GF↛TRD	18.504	5.487	0.146
TRD↛GF	9.977	0.564	0.82
GF↛GEE	-20.157	-10.441	0.015**
GEE↛GF	1.356	0.617	0.564
GF↛GDP	9.966	0.558	0.797

GDP↛GF	0.637	-0.627	0.578

Note: ** indicates 5% significance level.

According to the causality analysis findings, a one-way causality from the GF variable to NRD, PG, and GEE variables was identified in the BRICS-T country sample. No causal connection was found between the GF variable and the GDP and TRD variables. Theoretically, these findings suggest that green finance activities act as a leading macroeconomic indicator for shifts in natural resource allocation, demographic trends, and educational investments. In the Granger sense, early developments in green financial markets possess predictive power for subsequent macroeconomic and social adjustments. Rather than asserting a deterministic policy influence, this unidirectional causality implies that the expansion of sustainable finance infrastructure often precedes broader institutional and resource management shifts in emerging economies.

Robustness Test Results

The Panel ARDL method has been used to test the robustness of the long-term relationships obtained with the CCE and AMG methods. The short- and long-term parameter findings of the Panel ARDL method are presented in Table 7.

Table 7. Panel ARDL results

Dependent Variable: GF	Coefficient	Std. Error	t-Statistic
Long-Term Estimation Results			
NRP	-0.177	0.033	-5.429***
PG	-0.804	0.066	-7.007***
TRD	0.781	0.003	-10.109***
GEE	0.073	0.047	-11.534***
GDP	-0.031	0.015	-12.065***
Short-Term Estimation Results			
ECT (-1)	-0.663	0.163	-4.059***
dGF(-1)	0.017	0.166	0.102
dGF(-2)	0.344	0.138	2.490**
dNRP	-0.360	0.457	-0.788
dPG	7.158	4.280	1.672
dPG(-1)	-29.965	4.405	-6.802***
dPG(-2)	5.914	5.593	1.058
dTRD	-0.079	0.050	-1.595
dGEE	-0.260	0.203	-1.279
dGEE(-1)	-0.239	0.184	-1.301
dGEE(-2)	-0.793	0.233	-3.406***
dGDP	-0.086	0.033	-2.648**

Notes: *** and ** denote 1% and 5% significance level, respectively.

According to the Panel ARDL estimation results presented in Table 7, in the long term, a one-unit increase in the NRP variable reduces the GF variable by -0.177 units, while a one-

unit increase in the PG variable reduces the GF variable by -0.804 units. On the other hand, a one-unit increase in the TRD variable increases the GF variable by 0.781 units, and a one-unit increase in the GEE variable increases it by 0.073 units. Finally, a one-unit increase in the GDP variable reduces the GF variable by -0.031 units. The Panel ARDL estimation results presented are largely consistent with the previous long-term coefficient estimates obtained from CCE and AMG. According to the short-term parameter findings, the negative and statistically significant error correction coefficient of the model indicates that the error correction mechanism is working. It is observed that approximately 66% of the previous period deviations are quickly corrected, showing a tendency to return to equilibrium in the short term (ECT = -0.663). The two-period lagged green finance variable still has a positive and significant effect (dGF(-2) = 0.344), indicating that previous financial flows play a stimulating role in the sector's demand in the short term. On the other hand, the demographic pressure created by population growth from the previous period strongly limits green finance in the current period (dPG(-1) = -29.965), while two-period lagged education expenditures have the opposite effect, reducing green finance activities unexpectedly (dGEE(-2) = -0.793). Additionally, it has been observed that economic growth (dGDP = -0.086) has a restrictive effect on green finance in the short term, while the other short-term parameters are statistically insignificant.

7. DISCUSSION

The research findings indicate that there is a negative relationship between economic growth and green finance activities in the BRICS-T countries' economies. The long-term results from CCE, AMG, and Panel ARDL suggest that a one-unit increase in economic growth affects green finance activities by -0.029, -0.037, and -0.031, respectively, indicating a limited negative relationship between the two. Similarly, the short-term Panel ARDL findings confirm that economic growth has a constraining effect on green finance. This negative relationship can be theoretically grounded in the early stages of the Environmental Kuznets Curve (EKC) hypothesis and the 'crowding-out' effect within financial markets. In developing BRICS-T countries, rapid economic expansion is predominantly driven by the 'scale effect' of traditional, carbon-intensive industrialization rather than the 'technique effect' of environmentally friendly investments (Grossman & Krueger, 1995; Asif *et al.*, 2024). During periods of accelerated growth, high-yield traditional sectors, such as fossil fuels, mining, and heavy manufacturing, absorb the majority of available capital. This dynamic effectively crowds out nascent green finance initiatives, as investors prioritize immediate, high-return conventional assets over long-term sustainable projects. Consequently, macroeconomic priorities heavily favor immediate industrial output over long-term environmental sustainability, leaving green finance activities marginalized. Furthermore, the potential relaxation of environmental regulations to stimulate rapid growth exacerbates this negative relationship. This structural reality aligns with established literature indicating that, before reaching a specific income threshold (the EKC turning point), the financial systems of emerging economies systematically prioritize conventional, high-carbon assets, thereby creating a friction against green financial instruments (Adebayo & Kartal, 2023; Elhassan, 2025; Sajjad *et al.*, 2024). In this context, the focus of the present study on developing economies like BRICS-T suggests an important contribution to the literature by highlighting

that factors such as institutional capacity, environmental regulations, and financial system maturity can differentiate the growth-finance relationship.

The research findings reveal the positive effect of commercial activities on green finance in the BRICS-T countries. Long-term analyses using CCE, AMG, and Panel ARDL show that a one-unit increase in trade increases green finance activities by 0.638, 0.715, and 0.781, respectively. This finding indicates that improvements in commercial activities support green finance mechanisms in the long term and confirm the H2 hypothesis. Improvements in trade increase the accessibility of new sources for financing green projects, while trade agreements that prioritize environmental standards encourage resource allocation towards sustainable practices. These agreements contribute to the financing of green investments and accelerate the adoption of environmentally friendly production processes. The literature on the effect of trade on green finance generally emphasizes a positive relationship. Oanh (2024) and Qing *et al.* (2024) mention that trade openness indirectly supports green finance through sustainable development and green energy consumption, while Tariq *et al.* (2024) show that trade contributes to green growth by fostering environmental innovation. Ashraf *et al.* (2024) highlights the effect of digital trade in increasing green financial demand, and Xiao and Tabish (2025) demonstrate that trade has the strongest effect on green finance in G7 countries. In this context, the findings of this study on BRICS-T countries are consistent with the literature, demonstrating that this effect is also valid in developing economies and making a unique contribution to the field.

Another finding from this research is the negative effect of natural resource usage on green finance in BRICS-T countries. Long-term analyses using CCE, AMG, and Panel ARDL show that a one-unit increase in natural resource usage reduces green finance activities by -0.164, -0.145, and -0.177, respectively. Additionally, the results of the causality analysis reveal a one-way causal connection from green finance to natural resource usage. These findings indicate that increases in natural resource usage do not support green finance mechanisms in the long term, thus rejecting the H3 hypothesis. When natural resource revenues are primarily directed towards carbon-intensive sectors, environmental risk awareness weakens, and resources allocated to green finance activities are pushed into the background. Furthermore, the dependency of public budgets on resource revenues may hinder the development of financial channels necessary for green bonds and sustainable investment funds. The one-way causal connection from green finance to natural resource usage in the causality analysis suggests that green finance tools are still far from having the capacity to transform the current growth model. As a result, natural resource usage emerges as a factor that hinders green finance in BRICS-T countries. The literature presents two opposing trends regarding the impact of resource rents on green finance. Liang *et al.* (2024) and Raihan (2024) found that when managed properly, resource rents positively support green finance and financial development, while Yu (2024) and Sadiq *et al.* (2024) showed that in the case of China, resource revenues increase carbon emissions, but green finance tools play a role in limiting this effect. The studies by Yu (2024) and Sadiq *et al.* (2024) are like the findings of this research. On the other hand, Xiao and Tabish (2025) found a positive effect of natural resource usage on green finance in G7 countries. The findings from Liang *et al.* (2024), Raihan (2024), and Xiao and Tabish (2025) contrast with the results of this study.

Apart from economic factors, an increase in education expenditures has positively impacted green finance activities in the long term, according to the CCE, AMG, and Panel ARDL estimators, with values of 0.051, 0.108, and 0.073, respectively. In the short term,

however, it was observed that two-period lagged education expenditures had the opposite effect than expected, reducing green finance activities. In terms of causality connections, it was found that green finance can be a factor that influences changes in education expenditures. These results indicate that educational investments play a significant role in the development of environmental awareness-focused financing mechanisms in BRICS-T countries, supporting the H4 hypothesis. In these countries, the long-term increases in education expenditures strengthening green finance activities can be interpreted through four main channels. First, increasing educational investments enhances environmental expertise and skilled labor in the financial sector, thus improving the design capacity of green financial products. Second, rising financial literacy and sustainability awareness keep the demand for sustainable funds, such as green bonds and credits, active. Third, education-supported R&D accelerates green technologies and innovations, thereby increasing long-term investment opportunities. Lastly, educational investments can support socio-economic development, deepen public-private partnerships, and strengthen sustainable financing infrastructure. Studies by Lee *et al.* (2023) and Lee *et al.* (2025) show that human capital inputs strengthen green finance mechanisms; Žalėnienė and Pereira (2021) and Bhutta *et al.* (2022) highlight that higher education and transparency-focused educational programs increase demand for green bonds; Chen and Xie (2023) emphasize the critical role of educational investments in efficient resource allocation in the renewable energy sector. Liang *et al.* (2024) argue that education-focused strategies in resource-rich economies enhance green finance capacity, while Xiao and Tabish (2025) demonstrate the significant support of education expenditures for green finance in the G7 case. The findings of these studies are consistent with the results of this research. Most of the studies in this field, both in developed and developing countries, consistently confirm that educational investments enhance the capacity for green finance.

8. CONCLUSION AND POLICY IMPLICATIONS

This research examines the determinants of green finance activities in BRICS-T countries, focusing on economic growth, trade, natural resource usage, and education expenditures. In the established model, the population variable is used as a control variable. The findings reveal that, in the long term, increases in economic growth and natural resource usage respectively reduce green finance, whereas trade openness and education expenditures significantly strengthen green finance. In the short term, economic growth exerts negative pressure on green finance, while population growth is identified as a significant negative pressure factor both in the short and long term. These results suggest that traditional growth-focused strategies in developing economies like BRICS-T have the potential to overshadow environmentally friendly finance. However, sustainable international trade connections and education investments can significantly enhance the capacity for green finance. The negative impact of natural resource usage on green finance activities in BRICS-T countries is associated with the redirection of these resources to sectors that do not prioritize environmental sustainability.

The research findings offer several recommendations for policymakers in BRICS-T countries. The negative impact of economic growth on green finance stems from the fact that growth is largely based on traditional and non-environmentally friendly sectors. Therefore, prioritizing green industrialization strategies is essential. Measures such as carbon taxes, reducing fossil fuel subsidies, and incentives for renewable energy can help reduce the share

of carbon-intensive sectors. Strengthening environmental regulations can particularly support sustainable growth. Additionally, international collaborations and transparent reporting mechanisms can enhance access to green finance, strengthening the alignment between environmental goals and economic development. The positive impact of trade on green finance also presents a significant opportunity for BRICS-T countries. In this context, promoting green trade agreements and integrating environmental standards into international trade processes can steer companies towards sustainable production. Collaborating with international financial institutions to fund sustainable trade projects is another effective policy tool. Furthermore, developing green finance models and promoting these instruments through digital platforms can facilitate access to finance. Supporting green certification processes through training and consulting services for foreign trade companies facing challenges in accessing finance can further enhance this development.

To address the negative impact of natural resource usage on green finance, BRICS-T nations must implement macro-financial strategies that decouple resource rents from traditional carbon-intensive investments. Rather than relying on rigid mandates, policy frameworks should prioritize the gradual integration of resource-dependent sectors into the sustainable finance ecosystem. This can be achieved by enhancing environmental risk disclosure requirements and incentivizing resource efficiency within corporate financial reporting. By realigning the risk-return profiles of natural resource investments, policymakers can systematically reduce the friction against green financial instruments. Regional collaborations between countries could help develop resource management and green finance models. Lastly, the long-term support of green finance through education investments offers a strategic advantage for BRICS-T countries. In this context, policymakers should integrate environmental finance-themed educational programs into curricula and increase public interest in green investment instruments through financial literacy campaigns. Particularly, developing environmental awareness among younger generations will strengthen the foundations of a sustainable financial system. Public institutions, in collaboration with the private sector, should establish R&D laboratories and innovation centers focused on green technologies, and education budgets should be synchronized with green transformation projects to be used more effectively. Furthermore, the widespread adoption of green finance certification programs offered through digital education platforms will contribute to increasing the capacity of the qualified workforce.

While this study provides valuable macro-financial insights, its conclusions must be evaluated within the context of certain limitations, which simultaneously outline the scope for future research. First, the scope of the analysis is restricted to the BRICS-T economies; thus, the empirical findings may not be strictly generalizable to all emerging markets, low-income nations, or advanced economies with different institutional frameworks. Second, the green finance variable is proxied primarily through green bond issuances due to macro-level data availability constraints. This proxy, while robust, may not capture the entirety of green financial flows, such as private green equity, localized green bank loans, or micro-finance initiatives. Finally, the macro-level panel data approach utilized in this study precludes the observation of micro-level, firm-specific, or intra-sectoral dynamics. To build upon these findings, future research should address these limitations by incorporating micro-level corporate datasets, employing broader composite indices to measure the full spectrum of green finance, and conducting comparative analyses between the BRICS-T bloc and other regional economic integrations.

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