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Green Finance Dynamics in G7 Economies: Investigating the Contributions of Natural Resources, Trade, Education, and Economic Growth

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Abstract: Despite the growing emphasis on sustainable development, the role of green finance in the context of G7 economies remains largely unexplored. The increasing emphasis on green financial transformation motivates this study to analyze the influence of natural resources (NARSs), population (POPS), education (EDCT), trade (TRD), and economic growth (ECNG) on green finance (GRF) in G7. Using panel data from 1996 to 2021, this study employs the Pooled Mean Group Autoregressive Distributed Lag (PMG-ARDL) methodology to investigate both the long-run and short-run relationships among these variables. To address the issue of possible heterogeneity, this study uses Cross-Sectional Autoregressive Distributed Lag (CS-ARDL). Before applying the PMG-ARDL methodology, this study conducted a series of pretests to ensure data reliability and address potential endogeneity issues. These included tests for cross-sectional dependence, slope homogeneity, variance inflation factor (VIF) analysis, Cross-sectionally Augmented Im-Pesaran-Shin (CIPS) unit root testing, and the Westerlund cointegration test. The PMG-ARDL outcomes show a positive relationship between NARS, ECNG, POPS, TRD, EDCT, and GRF. Specifically, a 1% increase in NARS, ECNG, POPS, TRD, and EDCT leads to a corresponding increase in GRF by 0.050%, 1.98%, 1.81%, 0.62%, and 0.20%, respectively. This study provides valuable policy recommendations for G7 countries, emphasizing the need for targeted strategies to enhance green finance through the sustainable management of natural resources, economic growth, education, and trade.

Keywords: natural resources; green finance; education; PMG-ARDL; G7 countries

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1. Introduction

Sustainable financial development is vital for tackling climate change, resource depletion, and economic inequality. It ensures that financial systems support ECNG while protecting the environment and promoting social well-being. By prioritizing green investments and sustainable practices, it paves the way for a low-carbon and green future. In support of this, GRF has emerged as a pivotal tool for promoting sustainable development by integrating environmental considerations into financial systems and is considered a key component of sustainable financial development [1–3]. Furthermore, the global emphasis on transitioning towards low-carbon economies has heightened the significance of financial mechanisms that support green investments. Therefore, sustainable financial development, characterized by the alignment of ECNG with environmental and social objectives, is critical to ensuring a balance between economic progress and ecological preservation. In connection with current financial circumstances, G7 (United States, Canada, the United

Kingdom, Germany, France, Italy, and Japan) economies play a crucial role in driving GRF initiatives. These countries are the world's largest contributors to global GDP and leaders in international TRD and innovation [4]. However, understanding how factors such as NARS, TRD, EDCT, and ECNG influence GRF dynamics in G7 remains underexplored. Hence, this study aims to address this gap by examining the interplay between these variables. This contributes to fostering sustainable financial development in G7 and provides insights that can facilitate decision-making in these influential nations.

The role of G7 economies in shaping the world's financial, technological, and environmental aspects is crucial and commendable. These countries account for around 40% of global GDP and a significant share of international TRD and innovation [5]. Since 1996, these nations have taken major steps toward sustainability, including adopting the Kyoto Protocol (1997) and committing to the Paris Agreement (2015) to combat climate change. Due to timely initiatives, their leadership has driven advancements in renewable energy, sustainable development financing, and green technology innovation. Specifically, post-COVID-19, G7 countries have intensified efforts to align recovery plans with GRF and sustainability [6]. Out of several initiatives, such as the Build Back Better World (B3W) plan and increased investments in clean energy, circular economies, and low-carbon technologies highlight their commitment towards GRF and sustainability. Additionally, these economies have pledged significant funding to GRF mechanisms, such as the USD 100 billion annual commitment to climate finance, which can sufficiently help to achieve global sustainability targets [7]. Therefore, these advancements and steps highlight G7's pivotal role in shaping the global GRF agenda.

Furthermore, each country in the G7 group contributes significantly to dealing with the issues of financial obstacles and climate change. These countries are collectively playing an important role in advancing GRF and integrating sustainability into their financial systems. For example, the United States has strengthened its GRF initiatives with the Inflation Reduction Act, which promotes clean energy investments and carbon capture, aiming for net-zero emissions by 2050 [8]. Similarly, Canada, Germany, France, Italy, and Japan are all targeting carbon neutrality by 2050, with various strategies to support GRF. Additionally, Canada has committed to green bonds and clean energy investments by focusing on sustainable growth and carbon pricing, whereas Germany prioritizes green bonds and renewable energy investments. Among these nations, France is also driving GRF through the Sustainable Finance Roadmap and green bonds [4]. In the G7 bloc, Italy has also not placed itself behind in any way. They focus on renewable energy, energy efficiency, and, specifically, their Italy Green Economy Transition Fund, targeting carbon neutrality. Along with these nations, another important country of this group is Japan, which continues to build its GRF landscape with green bond markets and sustainable finance initiatives. Furthermore, the UK also aims for net-zero emissions by 2050 [9]. They aim to invest heavily in clean energy and GRF through the GRF Institute and the issuance of green sovereign bonds. Collectively, these countries are shaping global GRF markets and driving the transition toward a low-carbon economy.

The study variables are considered important in connection with GRF and environmental sustainability. Therefore, studying the impact of NARS, TRD, EDCT, and ECNG on GRF in G7 economies is essential due to their significant influence on global economic and environmental policies. Moreover, being leaders in innovation, TRD, and financial markets, G7 countries play an important role in shaping sustainable finance practices and driving the global transition to low-carbon economies [10]. As a result, understanding how these variables contribute to GRF can provide valuable insights for designing targeted policies by promoting green investments and ensuring that ECNG in these advanced economies aligns with sustainability goals. Furthermore, to see the behavioral trends of GRF for G7,

Figure 1 has been shown. It shows the patterns in GRF for G7 nations spanning from 1996 to 2021. Overall, there has been a clear and significant rise in GRF throughout the years, which suggests an increasing focus on ecologically friendly financing practices among the G7 nations. Although there are minor variations in GRF values on a yearly basis, the general pattern indicates a consistent upward trend, which demonstrates the combined endeavors of G7 nations in advancing GRF projects. The determination of G7 nations to solve environmental concerns and transition towards SSD is highlighted by this trend, which involves greater investment in GRF initiatives.

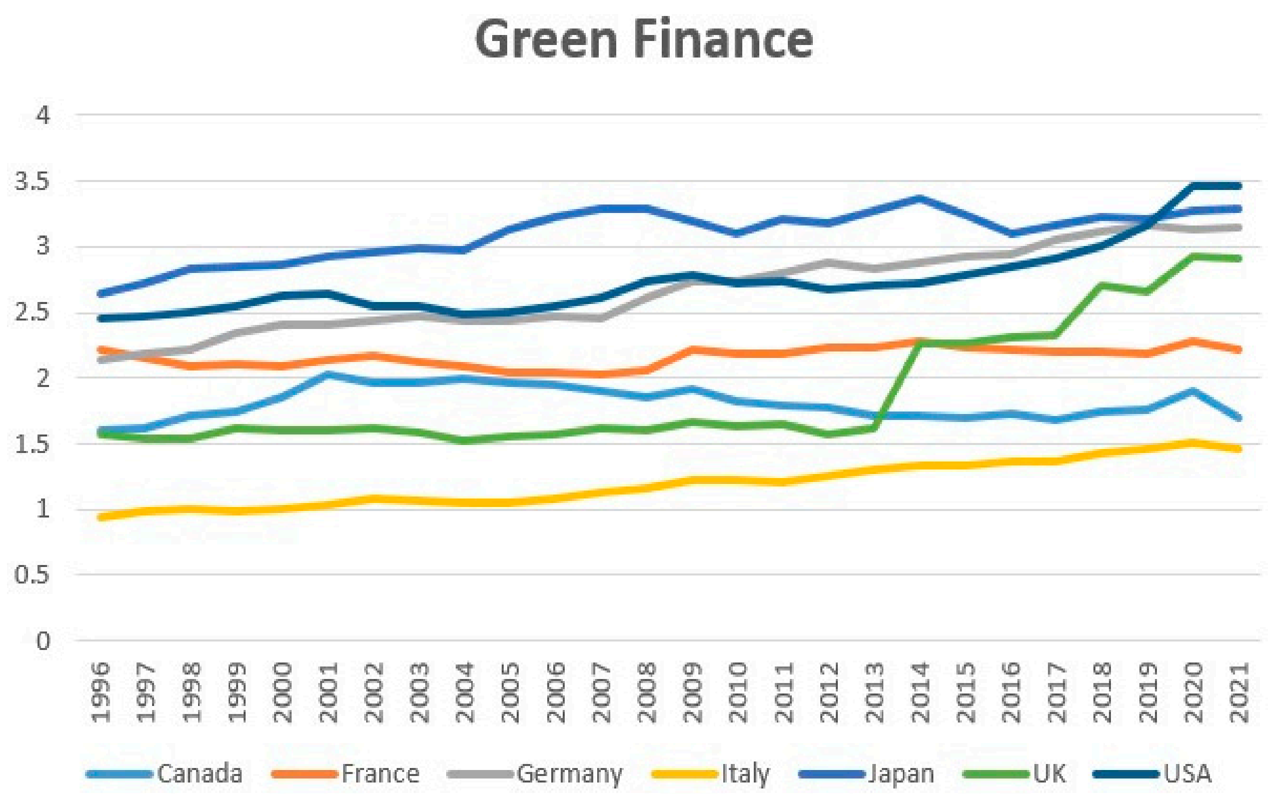

Figure 1. Trends of GRF in G7 countries.

Regarding the contributions, the findings of this study are expected to offer critical insights for policymakers in the G7 economies by exploring the dynamic relationships between NARS, TRD, EDCT, ECNG, and GRF. Therefore, by identifying how these variables interact with GRF, the study can guide the development of policies that promote sustainable financial practices. For example, it may suggest ways to integrate TRD policies that prioritize green products or highlight the importance of EDCT in equipping the workforce with the necessary skills for GRF innovations. Furthermore, the study can provide valuable data on the role of NARS in driving investment in sustainable projects, which can encourage governments to implement financial incentives such as subsidies or tax breaks to foster green investments. Furthermore, the ECNG component is crucial in understanding how prosperity can be aligned with sustainability goals to create a fertile ground for GRF initiatives. Moreover, by focusing on the G7 countries, which have advanced economies and diverse policy frameworks, the study can uncover nuanced insights into how these nations can leverage their unique economic and environmental contexts to drive GRF forward. The results of this research are expected to be highly relevant not only for the G7 but also for other countries aiming to integrate GRF into their economic systems. Based on the discussion, this study has the following research questions to answer:

1. What is the impact of natural resources on green finance in G7 economies?

2. How does trade influence the development and growth of green finance in G7 countries?
3. What role does education play in fostering the adoption and growth of green finance in the G7?
4. How does economic growth contribute to the evolution and expansion of green finance in G7 economies?
5. What is the impact of population growth on green finance dynamics in G7 countries?
6. What policy interventions can the G7 implement to boost green finance through the interplay of natural resources, education, trade, economic growth, and population?

The rest of the paper goes like this: Section 2 (Literature review) gives you a rundown of what other studies have said on the topic. Then, in Section 3 (Methodology), we dive into how we did our research. In Section 4 (Results), we discuss the findings. In Section 5 (Discussions), the study provides a detailed analysis of short-term and long-term results and a comparison with previous studies. Finally, in Section 6, we wrap it all up with conclusions and policy recommendations.

2. Literature Review

The recent literature has seen much discussion regarding the crucial role of GRF in promoting both ecological sustainability and ECNG [11–13]. The discourse around GRF is intricate and has many different aspects. Although there are persuasive justifications for allocating resources to sustainable practices, detractors also present legitimate apprehensions regarding the political intervention, economic strain, and technological obstacles [14]. A study by the authors of [15] has shown that GRF has a direct influence on ecological quality and itself is influenced by several factors like TRD, ECNG, and NARS. GRF is advantageous since it promotes sustainable habits in society. GRF promotes the adoption of sustainable practices by providing financial resources for eco-friendly projects. This encompasses the allocation of resources towards the development and utilization of sustainable energy sources, implementation of strategies to enhance energy efficiency and active participation in initiatives aimed at preserving NARS [16,17]. Multiple studies have examined various factors that impact GRF. Most studies have focused on ECNG, END, financial progress, TRD, and industrialization. The main factors influencing GRF during the past decade are considered to be CLC, ECNG, POPS, environmental deterioration, and capital accumulation [16–19].

2.1. Natural Resources and Green Finance Nexus

The connection between NARS and GRF has gained attention as scientists explore how resource management can drive sustainable financial systems [20]. Therefore, GRF, which includes investments and policies for environmental conservation, is considered essential for achieving sustainable development. In this association, for resource-rich nations the natural capital can play a key role in funding SDGs [21]. Therefore, NARS, such as fossil fuels, minerals, and agricultural land, have long driven ECNG. However, their management must align with sustainable development goals to avoid environmental degradation and depletion of resources. A study by [22] suggests that in GRF, NARS can support investments in renewable energy, energy efficiency, sustainable agriculture, and eco-friendly technologies. Additionally, the study by [23] finds that revenue from resource extraction can fund environmental projects. Moreover, another study by [24] suggests that countries with abundant resources can use these funds for green investments like renewable energy infrastructure and carbon capture technologies. By effectively managing and strategically utilizing resource rents, governments can balance ECNG with ecological protection. The work performed by the authors of [25] stresses the importance of aligning resource extraction with GRF, advocating for investments that minimize environmental harm and promote social well-being. Additionally, according to the findings of [26], NARS can support green bonds, a financial tool used to raise capital for sustainable projects. According to the findings of a study by [27] resource-rich economies like Canada, the U.S., and Australia, GRF plays a key role in ensuring environmental sustainability while leveraging NARS. Green bonds in these countries have funded renewable energy and conservation projects, using revenue from resource exploitation for low-carbon initiatives. However, regarding the success rate of GRF, a study by the authors of [28] highlights the challenges of over-reliance on extractive industries, noting that efficient resource management is crucial for the success of GRF. Another study by [29] highlights that integrating NARS with GRF faces challenges such as resource price volatility, especially in fossil fuels, which can destabilize investments in renewable energy. Furthermore, ref. [30] highlights that fluctuating oil and gas prices affect long-term renewable energy funding. Additionally, the environmental costs of resource extraction, like deforestation and pollution, can undermine GRF efforts [31]. Studies like [32] stress the need for policies regulating resource extraction to align with GRF, including carbon pricing and promoting the circular economy. Therefore, transitioning to low-carbon economies offers opportunities to diversify revenues through green technologies, bonds, and climate projects, as seen in the EU's sustainable resource initiatives. Based on the literature, this study proposes the following research hypothesis:

H1. *Natural resource extractions have a significant positive impact on green finance in G7 economies.*

2.2. Economic Growth and Green Finance Nexus

The interlink between ECNG and GRF has obtained significant attention in recent years, with studies highlighting that ECNG can create favorable conditions for the development of GRF mechanisms [33]. As economies expand, the demand for sustainable investments rises, leading to increased interest in green financial products like green bonds, loans, and sustainable investment funds [34]. Keeping in mind the importance of these relationships in developed economies such as the United States and the European Union, robust financial systems and well-established GRF frameworks have facilitated this transition. For example, green bond issuance in the U.S. reached a record USD 270 billion in 2020, supporting projects aimed at renewable energy and environmental conservation [35]. On a similar pattern, studies in Japan and the UK have shown that ECNG has bolstered GRF by fostering innovative financial instruments and policies, enabling investments in renewable energy, energy efficiency, and sustainable infrastructure [36]. However, the relationship is more important in emerging economies, where the impact of ECNG on GRF is shaped by factors such as financial inclusion and access to capital markets [37]. Furthermore, in countries like China, Brazil, and India, GRF has been growing alongside economic expansion, though challenges like limited access to GRF and dependence on fossil fuels persist [38]. Another research by [39] highlights that while ECNG in these countries has created opportunities for GRF, the volatility of resource prices has made it difficult to sustain long-term investments in green initiatives. Nevertheless, as these countries increasingly adopt green growth strategies, the role of GRF is expected to expand, with studies suggesting that integrating GRF into national development policies is crucial for achieving sustainable ECNG [40]. As a result, while ECNG fosters an environment conducive to GRF, the successful integration of GRF requires careful policy frameworks that address the challenges of financial inclusion and market instability. The study proposes the following research hypothesis.

H2. *Economic growth contributes significantly and positively to the evolution and expansion of green finance in G7 economies.*

2.3. Trade and Green Finance Nexus

The relationship between TRD and GRF has emerged as a critical area of study in recent years, with evidence suggesting that international TRD plays a significant role in the expansion of GRF [41]. According to the findings by the authors of [42], as global TRD increases, the demand for sustainable goods and services also increases, which in turn drives the need for green financial products to fund environmentally friendly initiatives. Furthermore, studies indicate that TRD liberalization, by enhancing market access, can create opportunities for cross-border investments in green technologies, renewable energy, and sustainable infrastructure [43]. Moreover, in particular, countries with robust trade agreements and international cooperation have been able to leverage GRF to support the financing of sustainable projects. For example, in the European Union, TRD policies that encourage sustainability have spurred investments in green bonds and green infrastructure, facilitating the transition to a low-carbon economy [44]. In comparison with emerging economies, the TRD-GRF nexus is also gaining traction, albeit with certain challenges. As a result, the study by the authors of [45] suggests that as TRD increases, the demand for eco-friendly products and services also rises, prompting these countries to explore GRF options, including green loans and green bonds, to support sustainable industries. Furthermore, a study by the authors of [46] suggests that TRD openness in countries like China and Brazil has contributed to the growth of GRF by promoting investments in green technologies. However, despite the increasing demand, the lack of comprehensive GRF policies and limited access to international GRF markets in some regions has hindered the growth of GRF [47]. In addition to this, TRD-related environmental policies, such as carbon tariffs or TRD restrictions on environmentally harmful goods, can further stimulate GRF by creating incentives for countries to invest in greener alternatives [48]. As a result, while TRD can stimulate demand for GRF, successful integration requires both international cooperation and domestic policy frameworks that encourage sustainable TRD practices and financial innovations. Based on the previous studies discussions, we propose the following research hypothesis:

H3. *Trade significantly fosters the development and growth of green finance in G7 countries.*

2.4. Population and Green Finance Nexus

The relationship between POPS growth and GRF has yielded both positive and negative insights in various studies [49]. On the one hand, POPS can drive the demand for sustainable projects, creating opportunities for GRF. Research in countries such as India and China has shown that growing POPS, coupled with urbanization, leads to increased demand for clean energy, waste management, and other eco-friendly infrastructure, which GRF mechanisms can help support [50]. These studies argue that as POPS expands, the need for sustainable technologies and green investments grows, prompting governments and financial institutions to create mechanisms, like green bonds, to support environmentally friendly projects [51]. However, other studies highlight negative implications as well. For example, rapid POPS in developing economies can exacerbate resource depletion and environmental degradation, limiting the effectiveness of GRF initiatives. Furthermore, research by [52] suggests that in low-income countries, the pressures from growing POPS often overshadow the ability of GRF to promote sustainability, as financial resources are diverted to immediate development needs such as healthcare and infrastructure. Additionally, studies from regions like Sub-Saharan Africa have pointed to challenges where insufficient GRF flows due to poor financial infrastructure and limited access to capital have hindered the ability to tackle the environmental effects of rapid POPS [53]. As a result, while POPS growth can open up opportunities for GRF by generating demand for sustainable projects, it also poses challenges that need to be addressed through targeted policies and investments to ensure its positive impact. After studying the literature on POPS, this work proposes the following research hypothesis:

H4. *Population growth has a significant positive impact on green finance dynamics in G7 countries.*

2.5. Education and Green Finance Nexus

The influence of EDCT on GRF has gained growing attention, as it is seen as a key factor in shaping the demand for sustainable financial products [54]. Studies such as by [55] suggest that a well-educated population, particularly in fields related to environmental sustainability, plays a significant role in promoting the growth of GRF. Furthermore, in countries with robust EDCT systems, such as the United States and Germany, studies suggest a clear correlation between higher EDCT levels and increased support for GRF initiatives, including the uptake of green bonds and sustainable investment practices [56]. This is because educated individuals are more likely to understand the importance of sustainability and the potential of green financial products, which in turn drives their adoption and use. In addition, educated POPS tend to support policies and regulations that promote green investment, further strengthening the link between EDCT and GRF [57]. However, the relationship is more complex in countries with less emphasis on sustainability EDCT. However, in emerging economies like India and Brazil, limited awareness and EDCT regarding GRF have been identified as key barriers to the growth of this sector. Research has pointed out that without proper EDCT on the benefits of green investments, there is limited public engagement with GRF products [58]. Furthermore, a lack of trained professionals capable of managing green investments can impede the development of a well-functioning GRF market, particularly in regions with low access to higher EDCT or where environmental EDCT is not prioritized [59]. As a conclusion, while EDCT has the potential to drive GRF, its absence or inadequacy in certain regions can significantly hinder the sector's progress. In connection with EDCT's past literature, this study has the following research hypothesis:

H5. *Education plays a significant positive role in promoting the adoption and growth of green finance in the G7.*

2.6. Literature Gap

While much research has focused on the relationship between TRD, POPS, EDCT, ECNG, and NARS with CO_2 emissions and ecological footprints, few studies explore GRF as a dependent variable. Most existing literature treats GRF as an independent variable, overlooking its role in response to the broader economic and environmental factors. This represents a key gap in understanding how variables like TRD, POPS dynamics, and ECNG influence GRF systems. Furthermore, no study has yet examined the combined impact of these factors—TRD, POPS, EDCT, ECNG, and NARS—on GRF, especially within the G7 context. Existing studies typically analyze these variables in isolation, but a comprehensive approach to their interconnected effects on GRF in advanced economies remains unexplored. The application of advanced econometric techniques, such as the PMG-ARDL and CS-ARDL models, adds value by offering deeper insights into the long- and short-term relationships between these variables. This methodology allows for more accurate modeling of the dynamics within G7 countries, where the effects of these factors may differ considerably. This gap underscores the need for research that integrates these key variables to provide a more holistic view of GRF, especially in the context of developed economies like G7.

3. Methodology

This study examines the role of natural resources, trade, education, economic growth, and POPS in shaping GRF dynamics in G7 economies. It aims to understand how these factors contribute to sustainable investment and policy frameworks that address environmental challenges. From a theoretical perspective, GRF is considered a transformative tool for achieving sustainable development by directing financial flows toward environmentally friendly projects. As a dependent variable, GRF is influenced by several key factors, including NARS, POPS, TRD, ECNG, and EDCT. Each of these independent variables plays a unique role in shaping GRF by creating a dynamic framework for understanding its determinants. According to the literature, NARS are considered integral to a nation's economic and environmental stability as they directly influence GRF. In this regard, resource-abundant countries often face environmental challenges such as resource depletion and ecological degradation, which increase the demand for GRF to fund sustainable initiatives like renewable energy, resource efficiency, and conservation projects [60]. Therefore, effective management of NARS through GRF can mitigate the adverse impacts of resource exploitation. A study by the authors of [61] suggests that resource-rich economies that integrate GRF into policy frameworks experience improved environmental performance and resource sustainability. As a result, NARS serves as both a driver and a beneficiary of GRF, with GRF playing a critical role in fostering sustainable resource management.

Similarly, POPS exerts significant pressure on environmental systems, increasing the need for GRF. Moreover, a larger POPS leads to greater demand for infrastructure, energy, and goods, all of which contribute to higher emissions and environmental degradation [62]. GRF addresses these challenges by financing green infrastructure, energy-efficient technologies, and sustainable urban development. Moreover, growing POPS can catalyze demand for innovative green products and solutions, encouraging investment in environmentally sustainable projects [63]. POPS dynamics also influence the allocation of GRF, as densely populated regions often prioritize investments in public transportation, waste management, and renewable energy projects to ensure sustainable urbanization. Meanwhile, TRD facilitates the exchange of goods, services, and technologies, significantly impacting GRF. Open economies often have greater access to advanced green technologies and environmentally friendly practices, promoting the adoption of GRF to support low-carbon development [64]. However, TRD can also lead to environmental challenges, such as increased pollution from production and transportation activities. In such cases, GRF plays a crucial role in mitigating these negative effects by funding clean technologies and encouraging compliance with international environmental standards [65]. Empirical evidence highlights that countries with higher TRD openness are more likely to allocate resources toward green financing, particularly for projects that align with global environmental goals.

Moreover, ECNG is also a key determinant of GRF, with its impact varying depending on the stage of development. The environmental Kuznets curve suggests that at lower levels of ECNG, environmental degradation increases; however, as income levels rise, societies tend to invest more in environmental protection, leading to increased GRF [66]. High-income countries often allocate significant financial resources to green projects, such as renewable energy, sustainable agriculture, and carbon capture technologies [67]. On the other hand, in lower-income economies, ECNG can amplify the need for GRF to address the adverse environmental effects of industrial expansion. Thus, ECNG serves as both a catalyst and a requirement for the expansion of GRF. Additionally, no society can deny the importance of EDCT. One of the reasons behind this is that EDCT plays a pivotal role in driving GRF by fostering awareness of environmental issues and building capacity for innovation. Higher levels of EDCT enhance societal understanding of sustainability challenges, increasing demand for environmentally responsible investments [68]. Moreover, EDCT promotes the development of green skills and technologies, which are essential for the successful implementation of GRF initiatives [69]. Policymakers and investors with strong educational backgrounds are more likely to prioritize green financing as they recognize its potential to drive sustainable development. Empirical studies have shown a positive relationship between EDCT levels and the adoption of green financial instruments, particularly in emerging economies seeking to balance ECNG with environmental conservation. To proceed with the analysis, the study utilized data from the World Bank Database and the OECD database to examine the influence of NARS, EDCT, TRD, POPS, and ECNG on GRF in G7 countries. The data used covers the period from 1996 to 2021 in a panel format. The details of these variables are displayed in Table 1.

Table 1. Variables and sources.

Variables	Short Forms	Source
Green Finance	GRF	OECD
Natural Resource Extraction	NARS	WDI
Population	POPS	WDI
Trade	TRD	WDI
Education	EDCT	WDI
Economic Growth	ECNG	WDI

Equation (1) has been utilized to examine the relationship between the study variables. The study uses a linear equation for the panel data model for several reasons. Linear models are commonly preferred in panel data analysis due to their simplicity, ease of interpretation, and the availability of well-established estimation techniques [70]. This approach provides a straightforward way to understand the marginal effects of independent variables on the dependent variable. Furthermore, linear models can yield reliable results when the relationships between the variables are expected to be approximately linear [71]. In cases where nonlinear models add complexity without significantly improving explanatory power, the linear model offers a more efficient and effective solution for analyzing the relationships in this study.

$$GRF_{it} = \alpha_0 + \alpha_1 NARS_{it} + \alpha_2 POPS_{it} + \alpha_3 TRD_{it} + \alpha_4 EDCT_{it} + \alpha_5 ECNG_{it} + \mu_{it} \quad (1)$$

GRF, NARS, POPS, TRD, EDCT, and ECNG represent green finance, natural resource extraction, population, trade, education, and economic growth, respectively. The symbol μ is used to denote the residual or error terms, where the subscript i represents cross-section and t indicates the time period.

When analyzing the long-term connection between the variables, it is crucial to initially establish the presence of any CD. In this regard, the co-integration models that do not account for CD are prone to generating unreliable results [72]. Recent research has once again provided evidence that unobserved common factors can lead to dependencies in residual terms over time. Therefore, these dependencies have the potential to produce misleading results in econometric models if they are not properly controlled for [73,74]. This study examined the issue by employing [75] CD test. The equation utilized in this experiment is presented below.

$$CD = \sqrt{\left(\frac{2T}{N(N-1)}\right)} \sum_{i=1}^{n-1} \sum_{j=i+1}^{N} (p_{ij}) N(0,\ 1) \quad (2)$$

From the above equation, N and T denote the cross-section dimension and time period, respectively. The term p_{ij} from the formula also represents the sample estimate of the pairwise correlation of the errors. In order to determine the presence of a unit root, the authors of [76] developed the CADF and CIPS tests, which take into account the cross-sectional reliance in the data. Conclusively, these tests are considered superior to the first-generation unit root test in terms of addressing cross-sectional dependency. However, we used the CIPS unit root test, and its equation is as follows:

$$\text{CIPS} = \left(\frac{1}{N}\right)\sum_{i=1}^{N} t_i(N,T) \tag{3}$$

This study uses the PMG-ARDL model developed by [77]. This model is applicable when the variables are stationary at I(0) or I(1), or a mix of the two, but not I(2). This model is feasible when the variables are stationary at I(0) or I(1) or a combination of both, but it is not applicable to I(2). The variables we are dealing with are stationary at their initial levels, after a difference of the first order, or a combination of both. In addition, this model offers the benefit of being capable of examining the effects of factors over both extended and immediate time periods. An advantage of this model, compared to others, is its ability to address issues such as endogeneity, heteroscedasticity, autocorrelation, and multicollinearity in models [78]. Hence, the PMG-ARDL model offers three options: PMG, MG, and DFE. After doing the Hausman test, the study decided to use the PMG method to evaluate the long-term connection. The mathematical formulas for the PMG are displayed here.

$$GRF_{it}\alpha_i + \sum_{J=1}^{p} \beta_{ij} GRF_{it-j} + \sum_{J=1}^{q} \delta_{ij} Z_{it-j} + \varepsilon_{it} \tag{4}$$

whereas,

$$Z_{it} = (NARS, POPS, TRD, EDCT, ECNG)$$

In Equation (4), α_i represents the fixed effects specific to each nation, b_{ij} represents the estimated parameters for lagged GRF, δ_{ij} represents the coefficients for the lagged explanatory variables, and ε_{it} represents the stochastic error term.

4. Results

Descriptive statistics for GRF, NARS, POPS, TRD, EDCT, and ECNG are presented in Table 2. Their mean and median show the central tendencies of each variable and minor differences that signify a possible skewness of the distribution. Standard deviations represent how the values vary around the mean; that is, the extent to which the variables fluctuate within the dataset. GRF and NARS demonstrate somewhat symmetrical distributions and moderate variability; simultaneously, POPS may have an extent of positive skewness and considerable variability. TRD depicts high variability in TRD volumes, and its mean substantially exceeds its median. EDCT presents a symmetrical distribution of moderate variability, while ECNG also shows a similar pattern of distribution of moderate variability. The variability of all variables is well emphasized by the difference between the minimum and maximum values for each, reflecting the diverse dataset in terms of government revenue, agricultural revenue share, POPS size, TRD volume, EDCT expenditure, and ECNG rates of the observed entities. These statistics are useful in understanding the dataset and possible trends and patterns.

Table 2. Descriptive statistics.

	GRF	NARS	POPS	TRD	EDCT	ECNG
Mean	2.223006	4.814709	0.661646	1.05×10^8	51.57466	39,159.68
Median	2.217655	4.862496	0.138428	66,030,574	54.86769	36,676.18
Maximum	3.467770	6.738698	5.564819	3.32×10^8	89.16109	61,829.85
Minimum	0.945900	3.077820	0.012489	29,610,218	18.12563	29,375.04
Std. Dev.	0.661733	0.868679	1.078648	86,123,327	18.48158	7383.336

In order to check the possible multicollinearity among the variables, we used the VIF test, and the results are presented in Table 3. The findings reveal that none of the variables exhibit a VIF value exceeding the commonly accepted threshold of 10, indicating the absence of severe multicollinearity. According to the outcomes of the VIF test, NARS has the highest VIF at 3.09, suggesting a moderate correlation with other variables but remaining within acceptable limits. At the same time, POPS follows with a VIF of 2.71, also reflecting a moderate association. Meanwhile, TRD, EDCT, and ECNG have relatively lower VIF values of 2.04, 1.73, and 1.39, respectively, showing a weaker correlation with other variables. Overall, these results confirm that multicollinearity is not a concern, ensuring the robustness and reliability of the regression analysis.

Table 3. VIF test.

Variables	VIF	1/VIF
NARS	3.09	0.323624
POPS	2.71	0.369003
TRD	2.04	0.490196
EDCT	1.73	0.578034
ECNG	1.39	0.719424

The econometric analysis commences by analyzing the data for CD and slope homogeneity (SH). Table 4 presents the results of the CD, providing evidence of the presence of CD in the data. The test data exhibit significance at the 1% level, so rejecting the null hypothesis of CD and affirming the concerns related to CD. This result is significant because of the interconnectedness of the G7 nations, which are all industrialized countries, particularly in terms of TRD flows. Consequently, a single economic level disturbance is expected to have comparable impacts on various countries.

Table 4. CD test.

Test	Statistic	Prob.
B-Pagan LM	99.00054 ***	0.0000
P-Scaled LM	10.95562 ***	0.0000
Pesaran CD	4.045407 ***	0.0001

Note: *** represents a significant level at 1%.

Furthermore, the SH test is conducted after the CD analysis. Table 5 displays the outcomes of the SH test. The test findings for the model are statistically significant, as indicated by the estimations. In order to confirm the presence of variations in slope within the data, the null hypothesis of homogeneity is rejected with a significance threshold of 1%. While the G7 nations share many similarities, there are also notable economic differences among them. Therefore, it is justified to have variation in slope in this particular circumstance.

Table 5. Slope test.

Test	Value	Prob.
Delta	7.899 ***	0.000
Adj. Delta	9.241 ***	0.000

Note: *** represents a significant level at 1%.

Once we have confirmed issues related to CD and SH in the data, we go ahead with co-integration and unit root studies. Since we have found CD issues, the first-generation tests are no longer suitable. To check stationarity, we use the second-generation CIPS test. Table 6 shows a quick summary of what we found. Initially, the series is not stationary, but they become so when we look at the first difference, according to our estimates. With a significant level of 1%, the test results are statistically significant, which means we reject the null hypothesis of the CIPS test, backing up our claims. Consequently, the factors analyzed in this study possess a shared level of integration. Co-integration analysis is conducted once the presence of unit roots has been confirmed.

Table 6. CIPS unit root test.

Series		I(0)	I(1)
GRF		−2.002	−3.885 ***
EDCT		−1.733	−4.919 ***
NARS		−1.638	−4.326 ***
POPS		−1.021	−3.894 ***
TRD		−1.581	−3.485 ***
ECNG		−2.810 *	−3.709 ***
Critical values:	−3.1 (1%)	−2.73 (10%)	−2.86 (5%)

Note: * and *** represent the significance level at 10% and 1%.

Table 7 gives a quick look at what the study in [79] found about co-integration. The model shows co-integration, which means the test statistics, like Gt and Pt values, are significant. Among the G7 nations, GRF is linked in the long-term with NARS, POPS, TRD, EDCT, and ECNG. Having these long-term connections makes it easier to figure out how variables relate over time.

Table 7. Westerlund co-integration test.

Statistic	Value	Z-Value	*p*-Value
Gt	−3.618 ***	−2.698	0.004
Ga	−11.764	1.031	0.849
Pt	−9.585 ***	−3.059	0.001
Pa	−13.060	−0.554	0.290

Note: *** represents a significant level at 1%.

Prior to examining the long-term and short-term associations between the research variables using PMG-ARDL, it is essential to do a Hausman test to determine whether we should proceed with PMG, MG, or DFE. The findings of the Hausman test are displayed in Table 8. The findings validate the use of PMG ARDL for assessing both long-run and short-run associations.

Table 8. Hausman test.

Test Summary	Chi-Stat	Prob.	Decision
PMG vs. MG	2.834312	0.4103	PMG
PMG vs. DFE	2.873321	0.4307	PMG

Once we have established the presence of co-integration between GRF and the regressors, we proceed to analyze the impact of NARS, POPS, TRD, EDCT, and ECNG on GRF using the PMG-ARDL method. The results of PMG-ARDL are displayed in Table 9. The table displays the coefficients and their corresponding t-statistics, as well as the level of significance, for each variable in the model. The coefficient estimates for NARS, POPS, EDCT, ECNG, and TRD are all positive and exhibit significance at the 1% level, as indicated by the presence of ***.

Table 9. PMG-ARDL test.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
		Long Run Equation		
EDCT	0.198501 ***	0.024586	8.073652	0.0000
NARS	0.050273 ***	0.013570	3.704617	0.0004
POPS	1.813105 **	0.695597	2.606546	0.0109
TRD	0.619672 ***	0.176784	3.505246	0.0008
ECNG	1.982193 ***	0.115796	17.11798	0.0000
		Short Run Equation		
ECT	−0.501552 **	0.196421	−2.553454	0.0126
EDCT	0.046973 **	0.020383	1.183210	0.0482
NARS	0.130242 ***	0.046210	2.818476	0.0061
POPS	5.06679 **	3.85485	1.802687	0.0130
TRD	0.715582 **	0.415427	1.192741	0.0484
ECNG	1.644991 **	1.711743	0.974451	0.0478

Note: ** and *** represent the significance level at 5% and 1%.

EDCT is essential for advancing GRF efforts and stimulating ECNG. EDCT empowers individuals to engage in sustainable economic activities by educating awareness, stimulating demand, and promoting innovation. The results show that EDCT has a significant and favorable impact on GRF. The PMG-ARDL approach shows a coefficient of 0.198501, which means a 1% increase in EDCT will bring a 0.1985% increase in the GRF of G7 countries. This implies that, while other variables stay unchanged, an elevation in life expectancy is linked to GRF. The link between EDCT and GRF is multifaceted and significant. EDCT plays a crucial role in enhancing environmental awareness and sustainability consciousness among individuals. It fosters innovation and entrepreneurial spirit, thereby encouraging the development of green technology and sustainable business practices. Additionally, higher levels of EDCT often correlate with increased political engagement, leading to advocacy for strategies promoting sustainability. Moreover, companies are increasingly driven to invest in sustainable practices due to growing social and environmental concerns. At the same time, NARS is essential for the economic progress and advancement of countries. Nevertheless, the exploitation and administration of NARS can also result in harmful consequences for the environment. The findings clearly demonstrate that NARS has a positive and statistically significant impact on GRF, as indicated by a coefficient of 0.050273.

This implies that a 1% rise in NARS will result in a corresponding increase in the level of GRF by 0.0503%. Figure 2 shows the relationships between NARS, TRD, POPS, ECNG, EDCT, and GRF.

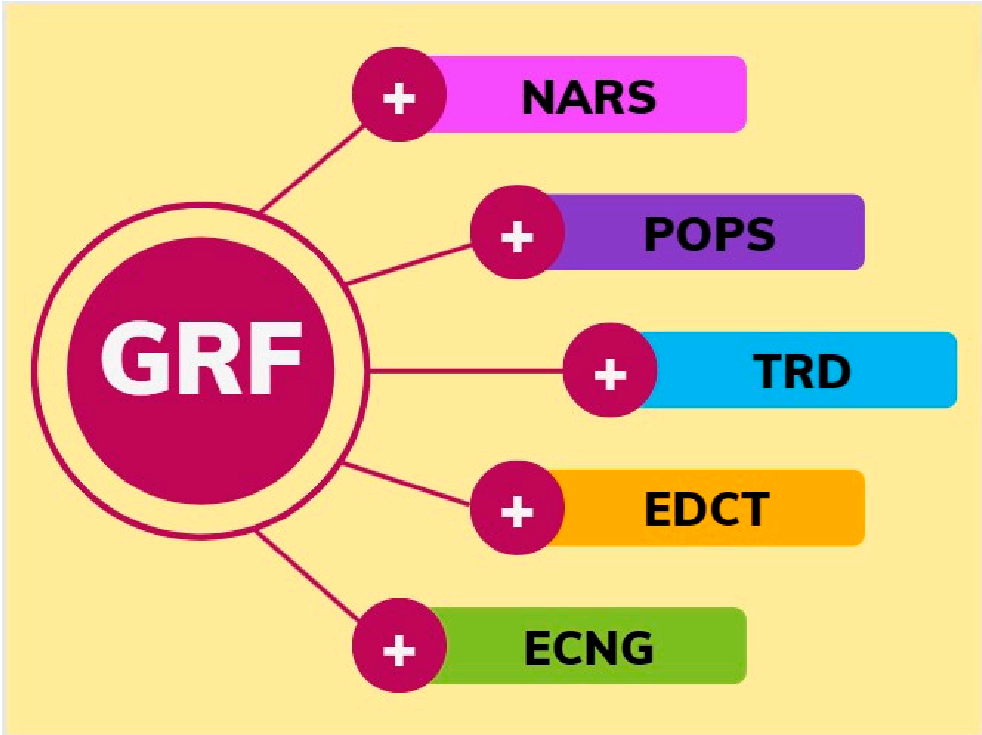

Figure 2. Relationships of the study variables.

Additionally, Table 9 demonstrates the existence of positive correlations between the control variables and GRF. For instance, when the value of POPS is 1.813105, it has a positive and statistically significant impact on GRF. This implies that a 1% rise in POPS will result in a corresponding increase in GRF at a rate of 1.8131%. This implies that, while all other variables remain unchanged, an increase in POPS is correlated with a rise in GRF in G7 nations. Similarly, the variable TRD has a strong and significant impact on the variable GRF, with a coefficient value of 0.619672. When all other factors are constant, an increase in TRD is linked to an increase in Long-term Government Financing. To be more precise, a 1% increase in TRD will result in a corresponding increase in GRF at a rate of 0.619672%.

There is a positive and significant association between ECNG and GRF. When the economy grows, there is a greater demand for green products and activities. This happens because more people and businesses are choosing to invest in sustainable practices and environmentally friendly projects. Our research shows that ECNG has a positive and significant impact on GRF. In the long term, for every 1% increase in ECNG, we can expect a corresponding 1.9822% increase in GRF. Essentially, when everything else stays the same, higher ECNG tends to lead to more investment in GRF. Moreover, all the short-term correlations between NARS, TRD, EDCT, ECNG, and POPS with GRF are positive and statistically significant: NARS is 1%, TRD equals 5%, EDCT equals 5%, and ECNG is 5%, while POPS is 5%. In other words, all independent dependent factors are causing an increase in GRF in G7 countries. Furthermore, the ECT value is negative and statistically significant at 1%.

Additionally, to address the issue of heterogeneity, the CS-ARDL test was conducted, and the results are presented in Table 10. The long-run results show that EDCT, NARS, POPS, TRD, and ECNG all have positive and statistically significant impacts, highlighting their critical roles in influencing the dependent variable over time. Similarly, in the short run, ECT is negative and significant, confirming the stability of the model and a convergence toward equilibrium. Additionally, EDCT, NARS, POPS, TRD, and ECNG also exhibit significant positive effects in the short run. These results demonstrate that the issue of heterogeneity has been effectively addressed, ensuring robust and reliable findings.

Table 10. CS-ARDL test.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Long Run Equation				
EDCT	0.14659 ***	0.04635	3.16222	0.0015
NARS	0.03264 ***	0.01265	2.58012	0.0098
POPS	1.32567 **	0.59410	2.23137	0.0256
TRD	0.46589 ***	0.17411	2.67582	0.0074
ECNG	1.65887 ***	0.57100	2.90521	0.0036
Short Run Equation				
ECT	−0.51265 **	0.23859	−2.14860	0.0316
EDCT	0.04697 *	0.02454	1.91384	0.0556
NARS	0.17659 ***	0.05477	3.22403	0.0012
POPS	1.45698 **	0.72236	2.01695	0.0436
TRD	0.18464 **	0.08831	2.09058	0.0365
ECNG	1.47665 **	0.70289	2.10082	0.0356

Note: *, **, and *** represent the significant level at 10%, 5%, and 1%, respectively.

5. Discussions

The results of PMG-ARDL indicate that NARS positively influences GRF in G7 not only in the long but also in the short run. In the long run, the coefficient of 0.050273 implies that a 1% increase in NARS contributes to a 0.0503% rise in GRF. This positive and significant relationship stresses the role of sustainable resource management in creating financial opportunities for green initiatives in G7. Meanwhile, the short-run coefficient of 0.130242 suggests that a 1% change in NARS generates a 0.1302% immediate increase in GRF. This outcome indicates that change in NARS in the short term can have a more definite effect on GRF by reflecting the sensitivity of financial mechanisms to resource availability and management practices. This outcome strongly supports the H1 hypothesis of the current study. The outcome aligns with expectations, as sustainable resource exploitation can generate the necessary financial inflows for green projects, while effective governance of these resources ensures their long-term contribution to green growth. The higher coefficient in the short run suggests that immediate revenues from NARS can provide quick funding for green projects. This could include financing for renewable energy infrastructure, reforestation programs, or environmental restoration initiatives. Whereas in the long run, sustainable management of NARS also creates a stable foundation for GRF. For example, investments in resource-efficient technologies and renewable resource utilization ensure a steady stream of green finance that supports large-scale sustainability initiatives. The relatively smaller coefficient reflects the gradual but consistent contribution of NARS to GRF over time. According to the literature, the NARS, when managed sustainably, enhances the GRF by channeling revenues toward projects that mitigate environmental degradation and promote eco-friendly development. However, over-reliance on resource exploitation without adequate conservation strategies could jeopardize these gains, emphasizing the need for a balanced approach that prioritizes renewable and sustainable resource use. The findings are consistent with prior research emphasizing the importance of NARS in driving green financial mechanisms. For instance, the authors of [80] found that NARS, when properly governed, significantly contributes to financing environmental projects in resource-abundant economies. Similarly, the authors of [81] highlighted the role of NARS in supporting clean energy transitions, particularly in advanced economies. This study bridges a critical gap in the literature by explicitly linking NARS with green financing in the context of the G7, where resource dependency is often complemented by advanced environmental governance frameworks. As a result, in the G7, NARS is key to funding green initiatives, as seen in Canada's renewable energy projects and Germany's green financing schemes. Therefore, short-run findings emphasize mobilizing immediate funds, while long-run results call for consistent policies to channel resource revenues into sustainable investments.

Another result of PMG-ARDL shows a robust and significant relationship between ECNG and GRF in the G7 countries. In the long run, the coefficient of 1.98219 suggests that a 1% increase in ECNG leads to a 1.982% increase in GRF. This highlights the critical role of a thriving economy in enhancing GRF by generating surplus resources and investment capacity for sustainable initiatives. Particularly, in the short run, the coefficient of 1.644991 indicates that a 1% increase in ECNG results in a 1.645% increase in GRF. Although the short-run impact is slightly lower than the long-run effect, it still demonstrates the immediate influence of ECNG on GRF, driven by revenue flows and policy priorities focused on sustainability. This result confirms the H2 hypothesis by underscoring ECNG as a vital driver of GRF. Both short- and long-run results align with the hypothesis that as economies expand, they allocate more financial resources to green projects, reflecting the positive spillover effects of growth. There are several causes of this relationship. For example, rapid increases in GDP provide immediate fiscal space for governments to allocate funds to green initiatives such as renewable energy projects and infrastructure development [82]. Furthermore, businesses experience higher revenues during periods of ECNG, enabling increased private-sector investments in sustainability-focused technologies and practices. As a result, strong economies are better positioned to meet international environmental commitments, such as the Paris Agreement, by financing large-scale sustainability projects and enhancing green technology development. However, without proper policies, the environmental costs of growth, such as increased resource consumption and emissions, may offset the gains in GRF. Furthermore, the findings are consistent with earlier research. For instance, the authors of [83] demonstrated that ECNG positively influences green investments by enhancing government revenue and private-sector financing. Similarly, the authors of [84] found that countries with higher GDPs tend to allocate more resources toward sustainability and green innovations. Moreover, the study extends the literature by emphasizing both the short- and long-term impacts of ECNG on GRF. While prior research often explored the relationship between growth and environmental quality, this study uniquely highlights how growth translates into actionable green financing, bridging a crucial research gap. The findings align with the G7's focus on leveraging economic strength for sustainability. Whereas Germany leads in solar and wind energy investments, Canada advances clean technologies, and the U.S. drives green innovation through initiatives like the Inflation Reduction Act [8]. Therefore, sustained growth enables G7 nations to achieve ambitious sustainability goals by integrating GRF into their strategies.

Furthermore, the results highlight the significant influence of TRD on GRF in the G7 countries. In the long run, the coefficient of 0.619672 indicates that a 1% increase in TRD leads to a 0.6197% increase in GRF. This highlights the vital role of TRD in sharing technology, capital, and knowledge across borders to boost GRF and sustainability efforts. Similarly, in the short run, the coefficient of 0.715582 suggests that a 1% rise in TRD results in a 0.7156% increase in GRF. The H3 hypothesis is supported by both the long-run and short-run findings. The literature validates that TRD emerges as a vital enabler of GRF, aligning with the view that TRD policies create opportunities for green investments by facilitating resource flows and technological advancements. There exists a strong reason behind this relationship, as suggested by [85] that an increased TRD enables the rapid diffusion of green technologies, which drives immediate financial flows toward sustainability initiatives. As a result, TRD contributes to the structural transformation of economies, enabling the adoption of cleaner production processes and sustainable resource management, which boosts GRF. Furthermore, TRD agreements that prioritize environmental standards encourage countries to allocate more resources to sustainable practices, ensuring steady growth in GRF. Furthermore, TRD positively influences GRF by supporting the financing of renewable energy projects, eco-friendly infrastructure, and sustainable urbanization. However, policymakers must ensure that trade-led growth aligns with sustainability goals. Moreover, the findings are consistent with earlier studies that emphasize the role of TRD in promoting environmental sustainability. For instance, the authors of [86] argued that TRD accelerates the adoption of green technologies and attracts foreign investments in sustainable development. In a similar way, the authors of [87] demonstrated that TRD fosters green innovation and financing by facilitating knowledge-sharing and technological transfer. As a result, this study advances the literature by highlighting the dual short- and long-term impacts of TRD on GRF. While prior research often focused on either ECNG or emissions as outcomes of TRD, this study bridges the gap by focusing on its contribution to green financing, addressing a critical area in the sustainability discourse. Furthermore, TRD has been a cornerstone of economic policies in G7 countries, making this finding particularly relevant. In the short run, TRD agreements, such as the European Union's Green Deal, have spurred immediate financial flows into environmentally friendly projects within G7 economies. These agreements promote the use of green technologies and foster cross-border collaboration. In the long run, sustained TRD openness has allowed G7 countries to integrate sustainable practices into their economic structures. For example, Canada's TRD partnerships have supported the development of green energy projects, such as hydropower and wind energy, with long-term environmental benefits.

The next empirical result of PMG-ARDL demonstrates that POPS also positively influences GRF in the G7 economies. In the long run, the coefficient of 1.813105 indicates that a 1% increase in POPS leads to a 1.8131% rise in GRF. This shows how POPS boosts the workforce, consumer demand, and environmental awareness, driving green investments. Whereas in the short term, a 1% rise in POPS leads to a 5.07% increase in GRF, highlighting the immediate demand and opportunities POPS brings to GRF. This result confirms the validation of the study's H4 hypothesis. According to study outcomes, POPS in the short-term increases demand for green infrastructure. The larger the POPS, the more urgent the need to finance such projects. Whereas in the long term, POPS contributes to ECNG and a larger tax base, which can be directed toward sustainable financing initiatives. The study results align with prior studies emphasizing the critical role of POPS in driving GRF and sustainability. For example, the authors of [88] found that POPS stimulates demand for eco-friendly infrastructure, promoting investments in GRF. Similarly, the authors of [89] highlighted that POPS creates opportunities for governments to implement large-scale environmental projects supported by increased economic activity. This study adds to the literature by providing a dual perspective on the short- and long-term impacts of POPS on GRF. While prior studies have often focused on POPS as a driver of environmental degradation, this research shifts the focus to its role as a potential enabler of sustainable finance, thus addressing a notable gap.

The findings reveal that EDCT positively impacts GRF in the G7 countries, both in the long run and short run. In the long run, the coefficient of 0.198501 suggests that a 1% increase in EDCT leads to a 0.1985% increase in GRF. This result implies that investments in EDCT create a profound contribution to fostering environmentally conscious financing mechanisms in G7. In the current G7 landscape, EDCT plays a pivotal role in advancing sustainable development. Countries like Germany and Canada have integrated sustainability into their curricula, equipping individuals with green skills essential for the transition to a low-carbon economy. This study underscores the importance of such efforts, showing how EDCT not only boosts environmental awareness but also fortifies financial systems to support green transitions. The prominent long-term effects highlight the need for continued investment in EDCT to develop a workforce capable of tackling evolving sustainability challenges. Meanwhile, the modest short-term impacts call for immediate complementary measures, such as incentivizing green financial products, to accelerate tangible outcomes. Additionally, according to the findings of [90], EDCT is considered a driver of knowledge, innovation, and environmental awareness that appears to play a pivotal role in aligning financial systems with sustainability goals in the G7. Moreover, in the short run, the coefficient of 0.046973 indicates that a 1% rise in EDCT resulted in a 0.0469% increase in GRF. However, the magnitude of the effect is smaller compared to the long run. Still, it remains statistically significant, signifying that even immediate advancements in EDCT can create momentum toward achieving environmentally sustainable financing practices. Furthermore, the outcomes strongly validate the H5 hypothesis of the current study. The statistically significant coefficients, both in the long run and the short run, confirm that EDCT is a critical enabler of GRF mechanisms in the G7 economies. This outcome very well aligns with theoretical expectations that EDCT equips individuals and institutions with the skills and knowledge necessary for fostering environmental sustainability and green financial innovation. There is a strong theoretical concept behind the positive association between EDCT and GRF. According to the literature, the positive impact of EDCT on GRF can be attributed to its role in promoting environmental awareness, fostering green entrepreneurship, and enabling technological innovation. Therefore, in the short run, EDCT boosts immediate awareness among stakeholders by encouraging the adoption of sustainable financial instruments such as green bonds or ESG-focused funds. However, in the long run, the EDCT builds a more comprehensive interconnectedness between financial markets and ecological systems, which in turn leads to structural changes, such as the integration of sustainability metrics into investment decision-making and broader institutional support for green initiatives. Therefore, by strengthening the link between education and financing, G7 countries are better positioned to meet their sustainability targets under frameworks such as the Paris Agreement and the United Nations' Sustainable Development Goals. The current study findings support prior research emphasizing the role of EDCT in promoting sustainability-focused financial practices. For example, the authors of [91] linked higher education to eco-friendly investments, while [92] highlighted its influence on societal sustainability attitudes.

6. Conclusions and Policy Implications

The motivation behind this study stems from the pressing need to address sustainability challenges in a rapidly evolving global economic and environmental landscape. While the G7 nations have demonstrated leadership in sustainable development, the integration of key drivers like education, natural resources, trade, population growth, and economic growth into green financing systems remains underexplored. This gap requires immediate attention to design policies that effectively align economic growth with environmental sustainability goals. The study specifically addresses this issue by examining how these factors contribute to green finance, offering both short- and long-term insights. For analysis purposes, the study utilizes panel data from the World Bank and OECD databases, covering the period from 1996 to 2021.

To achieve research objectives, the study employed a robust methodological framework, incorporating cross-sectional dependence tests, slope homogeneity tests, the Variance Inflation Factor test, the CIPS unit root test, and the Westerlund co-integration test. For model estimation, it utilized the PMG-ARDL framework, followed by CS-ARDL as a robustness check. The findings reveal significant long-run contributions of education, natural resources, population, trade, and economic growth to green finance, with coefficients of 0.1985, 0.0503, 1.8131, 0.6197, and 1.9822, respectively. In the short run, ECT shows a significant adjustment speed (−0.5016), while variables like EDCT, NARS, POPS, TRD, and ECNG demonstrate positive and significant impacts, indicating the immediate and cumulative importance of these factors. These results highlight the need for sustained investments in education and resource management, coupled with trade facilitation and inclusive economic policies, to foster green transitions in advanced economies.

Based on this study's findings, the following policy recommendations are proposed to enhance the effectiveness of green financing and sustainability initiatives:

- As this study's findings show that EDCT has a significant positive relationship with GRF in the long run, policymakers in G7 countries should prioritize increasing investments in EDCT, particularly in technological and digital literacy. By focusing on these areas, G7 nations can better equip their workforce with the skills needed to drive sustainable ECNG and foster green investments. This approach will not only enhance long-term environmental sustainability but also strengthen the financial systems necessary to support green transitions. Moreover, short-term policies should target immediate skill development and provide incentives for EDCT in green technology and sustainability. This can include targeted programs, funding for educational institutions, and public-private partnerships;
- As another outcome shows a positive long-run relationship between NARS and GRF. As a result, the governments in G7 countries should implement policies that promote the efficient and sustainable use of NARS. This could involve adopting sustainable extraction methods and providing incentives for private investment in green technologies. Similarly, in the short run, immediate interventions should focus on introducing resource efficiency programs and promoting eco-friendly technologies for resource extraction, ensuring that short-term economic gains do not come at the expense of environmental sustainability;
- Similarly, according to the findings of this study, a positive long-run impact of POPS on GRF suggests that governments in G7 countries should implement policies that manage POPS in alignment with sustainability goals. This can be done by promoting family planning, encouraging sustainable urban development, and investing in social welfare programs. On the other hand, in the short run, immediate policies should focus on addressing the challenges posed by POPS, such as improving access to basic services, healthcare, and environmental awareness programs, ensuring that the POPS does not hinder sustainability efforts. These actions will help balance demographic trends with the need for long-term environmental sustainability;
- Furthermore, the study outcomes show a positive long-run relationship between TRD and GRF. Therefore, the governments in G7 countries should prioritize TRD policies that support the flow of green technologies and environmentally friendly products. This could be achieved by facilitating international collaboration on environmental policies and fostering TRD agreements focused on sustainability. In the short run, TRD policies should incentivize the import and export of green technologies, offering tax

incentives, facilitating TRD, and imposing green tariffs on environmentally harmful products. These measures will align TRD practices with sustainability objectives and enhance green financing efforts;

- Finally, the study outcomes show a positive relationship between ECNG and GRF. As an action, the policymakers in G7 countries should align ECNG strategies with sustainability targets. Long-term policies should focus on incentivizing low-carbon industries, fostering innovation in green technologies, and ensuring that ECNG contributes to environmental sustainability. In the short run, governments should stimulate growth in green sectors, such as renewable energy, by providing grants, subsidies, and low-interest loans to green entrepreneurs and companies. Such actions will support both ECNG and the transition to a sustainable, low-carbon economy.

These recommendations are designed to help G7 countries boost green finance and achieve long-term sustainability. By focusing on the study's key findings, the proposed policies aim to encourage sustainable investments, support eco-friendly industries, and develop green financial systems. In doing so, these strategies will drive ECNG while also protecting the environment for future generations.

According to the outcomes of this work, there are other potential paths that can be followed in the future. Hence, the findings of this study serve as a foundation for future exploration of the correlation between NARS, EDCT, and GRF. Subsequent research can investigate additional factors that may influence GRF, as well as the effects of policy interventions on the connection between these variables. However, the scope of this study was limited to G7 countries exclusively. Subsequent research can enhance this study by investigating the correlation between NARS, EDCT, and GRF across several panels. Additionally, conducting cross-country studies can offer valuable acumens into the applicability of the findings and assist in identifying regional variations in the factors influencing GRF. This study employed panel data, and future research might employ time series data to examine the evolution of the correlation between NARS, EDCT, and GRF over time. Subsequent studies can investigate the influence of governmental interventions on the correlation between NARS, EDCT, and GRF. These studies can offer valuable information about the efficacy of policy measures that try to encourage GRF and how they interact with other factors that influence GRF.

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Abbreviations

The following abbreviations are used in this manuscript:

CD	Cross-Sectional Dependence
CIPS	Cross-sectionally Augmented Im-Pesaran-Shin
CS-ARDL	Cross-Sectional Autoregressive Distributed Lag

EDCT	Education
ECNG	Economic Growth
GRF	Green Finance
NARS	Natural Resource Extraction
POPS	Population Growth
PMG-ARDL	Pooled Mean Group Autoregressive Distributed Lag
TRD	Trade

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