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Green Economic Growth and Environmental Governance: A Panel Analysis of G-20 Countries

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Abstract

Green economic development is an important solution to the burns because it is the only solution to both sustaining economic growth and offsetting the effects of environmental degradation. In that regard, green finance is at the center stage as it helps to attract funds toward renewable energy, low-carbon infrastructure, and environmentally responsible industries, but in many cases, how effective it would be can hinge on the strength of institutional structures. The current paper explores the co-relationship among green finance, green economic development within G-20 economies in the years 1995 to 2023, and how this is mediated by environmental governance. The analysis based on secondary panel data is conducted using the data provided by OECD, WDI, and World Bank, and applies econometric models that use direct and interaction effects. Descriptive outcomes provide insight into whether G20 economies vary in their financial outlays of environmental projects, quality of governance, and green growth outcomes. Correlations show that there are affirmative correlations among green finance and its governance and income levels, with surprisingly appearing negative correlations between both finance and governance, implying potential policy flaws or misalignment inherent in both policies. The results of the regression indicate that green finance and also the variable environmental governance have positive but statistically non-significant effects on green economic growth, whereas the cross-effect variable is negative in value and statistically non-significant as well, which integrates the complexity of linking financial flows to green results. The assumption that a sustainable, economic prosperity can and will be spawned by green finance alone is unsustainable; the inadequacy is attributable to the absence of unified governance structures, the absence of harmonized policies, and the inefficient development of the institutions. The paper also argues that the substantive resolution of sustainability transitions witnessed in G-20 economies is inevitably limited by how green fiscal tools are integrated into the dataset encompassing strong measures of governance, innovation volume, and economic balance to minimize climate-changing effects on both the environment and the economy.

Keywords: *Green Finance, Green Economic Growth, Environmental Governance*

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1. INTRODUCTION

The continuous chase after economic growth, in its turn, has occupied leading roles of the national policies agenda since as early as the pre-modern era because of the ultimate desire to help optimize the living standards and to create prosperity. However, the adverse effects of this virulent growth often have a negative environmental impact because these changes may be characterized by uncontrollable industrialization, excessive use of natural resources, and a conspicuous increase in pollution rates (Sadiq et al., 2025; Ali et al., 2025). These adverse impacts have led to questions about conventional development concepts and, as a result, have become an increasingly popular place for green economic growth approaches. So, the green economic growth is a paradigm shift that symbolizes the coupling of the development of the economy and the development of the environment, therefore achieving urgently required, ecology-centered, green sustainable development and world safe development. The principle was first given institutionalized status when the United Nations Economic and Social Commission for Asia and the Pacific formally introduced it at full

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scale in 2005, with a mandate to channel the high-growth-rate economies of Asia onto more sustainable environmental development paths. Since then, green growth has been adopted by a variety of policy discourses across the world. In contrast to the traditional growth models, green growth actively tries to reconcile the development goals and the environmental management with a strong focus on the preservation of biodiversity, the reasonable exploitation of natural resources, and ecological integrity maintenance (Al Masri & Wimanda, 2024; Khan et al., 2025; Ali et al., 2025). It is especially relevant to this strategy in the framework of climate change and ecological decline, in which the economies have to balance the expansionary requirements with sustainability principles. Additionally, the level of environmental worth of green economic growth is significant to resource intensive areas of Latin America, where responsible resource utilization can be used to implement renewable energy changes and enhance inclusive growth (Barbier, 2011; Hallegatte et al., 2012; Organisation for Economic Co-operation and Development, 2011; Sachs et al., 2019; United Nations Economic and Social Commission of Asia and the Pacific, 2005; Chaudhry et al., 2021; Jamel & Zhang, 2024; Khalid et al., 2025; Anus et al., 2025; Marc et al., 2025).

A long-term state financing of environmental research and development becomes essential to the growth of green economies and curbing environmental pollution. The movement towards the sustainable government regime is influenced by continuous innovation of clean technologies, which can stop any harmful emissions, but at the same time make production processes more efficient. Modern researchers and policy makers have indicated that technological innovation and green industrial processes play an important role in driving this green change. Namely, BRICS countries have enhanced the policy emphasis on low-carbon economic development, in the hope of making economic development more compatible with environmental protection. However, the extent and magnitude of environmental expenditures of the state vary widely in contexts of national settings, and each needs a national policy infrastructure of individual capacity, degradation of environment and readiness of the state. Govern parliamentary bodies are urged to favour the investment in local sectors for achieving best results, ripe as are renewable energy and green infrastructure, the circular economy. These fiscal allocations must be provided with stringent monitoring systems, in terms of performance milestones and open appraisal standards within set periods of time, to prove that environmental goals are met within the stipulated periods. The result is that the foundations of low-carbon development, resource optimization, and intergenerational sustainability are supported by green economic growth, which makes it second to none in terms of holistic socio-economic progress (Aghion et al., 2016; Dutz et al., 2018; Sovacool et al., 2020; Zhang et al., 2022; Singh & Kumar, 2023; Chaudhry et al., 2024).

Green economic growth is now considered to be achievable with the help of the strategic use of green finance, with the distribution of capital to eco-friendly projects, environmentally oriented innovations, and environmentally friendly businesses (Wang & Manopimoke, 2023; Wang & Li, 2024). A policy tool, green finance reduces the gap in financial resources and ecosystem goals, suitably aligning the national and corporate investments into areas that do not harm the environment and instead yield a green economy. Even though the increased institutionalization of green finance in less than twenty years happened more recently, history traces its origins to the environmental movements and regulatory changes in green finance in European nations like Sweden and Germany in the 1970s. The initiatives are the first steps in terms of both social awareness regarding the ecological boom that uncontrolled industrial growth requires and the willingness to balance economic robustness and environmental conservation. The intersection of green finance and digital financial technologies (more commonly referred to as financial technology) in recent years has enhanced transparency, enabled better tracking of green investments, and increased access to green financing tools. The convergence has offered a solution to the operational and informational bottlenecks that traditionally render the development of green financial systems challenging. Furthermore, green finance establishes a paradigm change by integrating environmental sensitization into credit analysis, investment portfolios, and funding structures. It works on the sustainability development concepts through funding new projects on renewable energy sources, low-emission transport networks, the material of energy-efficient infrastructure, climate corruption measures, etc. Green finance is a term of new development agendas in developed and developing standard economies with the incentive mechanism of financial profitability and environmental stewardship, utilizing new incentive mechanisms. The conceptual framework is then empirically implemented in terms of accumulation of insight from the dynamics using literature (such as Campiglio et al. 2018; Chenet et al. 2021; Mazzucato and Semieniuk 2018; United Nations Environment Program 2016; Volz et al. 2020; Ramanust 2023).

Applying the intersectional perspectives further, compared to renewable energy qualification and different technologies, compared to the emission trading qualification policies, green bonds solidarity is further demonstrated; the low carbon greening finance is again an important aspect in decreasing ecological risky issues and low carbon inclusive investing procedure. First, for green financial instruments, and particularly the advancement of green bonds, an upregulation of the concentration of capital flows into micro-apparifer infrastructure environment that are intensive green and climate-tolerant, to reshape the long-term evolution of the geo-path of the ecological goal. These mechanisms are in turn supplemented with strong governance tools in the environment, ensuring the location of regulations and continuity of financing (i.e. integrity and effectiveness of sustainable finance) and funding (i.e. fiscal tools, e.g. downwards taxes and subsidies). They also provide existing economic mechanisms of policy deregulation (like regulatory fungibility and regularity of reporting) and periodic investment efforts which allow the valuation of a systematic investor trust, that if applied in broader scope will lead to the tax cuts and subsidies thus giving credence to green investment projects. This interaction is very topical for rapidly growing economies of BRICS (Brazil, Russia, India, China, South Africa and other countries), where growth in the volume of production becomes as much a problem as even a challenge of transition to a sustainable development. The empirical literature has found that policy tools in the form of

environmental taxes, pricing measures, spatial features, and the stringency of regulatory policies can enable the transition towards renewable energy plants; avoid emissions; and induce structural and transformational redistribution in energy-intensive sectors. Therefore, even regarding the atmosphere and sustainable development, application of standards of environmental regulations and green financing policies improves sustainable development programmes and avoids further serious economic crunches at more high risks under the impact of climate change, as emphasized by Flammer (2021), Narasimhan et al. (2018), OECD (2018), Scholtens (2017), Audi et al., (2020) Taghizadeh et al. (2020) Kosyak & Popov (2020), Al-Masri & Ibrahim (2025).

2. LITERATURE REVIEW

Sustainable economic development has a strong correlation with environmental conservation, as green economic development provides a great way to achieve sustainable growth as long supported on the best basis of investments. Compounded over time, even small temporary investments could generate an enormous leverage, as long as they are targeted judiciously and strategically towards renewable energy policies, generic infrastructure, and environmentally conscious industries. Hydropower is a traditional driver of renewable energy that has been used in specific portions and resource-rich geographic areas, which has established the opportunity for a number of options required for initiating clean energy exchange (Ali et al., 2025).

Green economic development frequently generates extensive co-benefits, for instance, improved food security and increased access to energy, as it is built. Empirical evidence shows that although the expansion of renewable energy can most likely benefit agricultural productivity and the resilience of agro-ecosystems, favoring industrial progress may make resource scarcity worse and, potentially, destabilize food stocks. Another problem of green growth is the so-called resource curse: resource industries that drive economic development through natural resources tend to fail environmentally and economically. However, with the clean technologies and the diversification of extractive industries coming around the corner, all of this trend stands to change. In addition, the more the country engages in international trade, the greater the merits of green development are likely to be as a result of the ability to transfer information, spread technology, and adopt sustainable production. To ensure the maximum seizing of these benefits, governments should take proper precautions to control the risks associated with trade, including fluctuation in prices, inflation, and ecological damage. Lastly, the innovative green is one of the pillars of environmental development, which is a new product, service, and system of a lesser environmental pressure. The investments made in clean energy technologies replace polluting analogs, contribute to the realization of the long-term sustainability and climate objectives in most industries (Dutu and Sicari, 2016; Lo et al., 2021; Ozturk and Sharif, 2022; Peters et al., 2012; Sovacool et al., 2021; World Bank, 2020).

Great challenges fall on green financial vehicles, which are backed up by research and development in order to support international efforts for promotion of energy and reduction of greenhouse gas emissions. The two pillars finance and innovation are catalyzing factors for the implementation of renewable technologies and instruments of structural transition to a sustainable paradigm of low-carbon development. Green finance is innovative in that it focuses its investment on green projects such as solar, wind power projects, hydroelectric projects etc. At the same time, non-carbon intensive technologies have the hope of replacing traditional industry processes through the development of new scientific discoveries and investment in research and development. This kind of finance-innovation synergy is of paramount importance to emerging economies, including members of the BRICS, who have to strike the right balance between both sustainable development and fast rates of industrial expansion and associated growing energy demands. Research shows that as several green financing areas become more efficient, thereby increasing the scope, priorities are centered on when the distinct line of action to design such targets is appropriated in such a way that renders green commerce proposed through e-commercial platforms more profitable and productive over time. Startups in China and other developing countries in particular do an excellent job of tying economic development goals to carbon-reducing goals. The green credit, green bond, and that advantageous standpoint policy have been effective actually in cutting down the amount of carbon dioxide and other pollutants given off from these heavy industries. In addition to making a successful transition to reduce greenhouse gas emissions, Singapore requires long-term sustainability in the environment while also enabling long-term competitiveness through continuous innovation in clean energy systems, smart-grid systems, and low-emissions technologies. Green finance is already becoming established in various countries, with carbon-neutrality targets for private finance, and could provide a significant advance internationally in terms of the financial regulation approach to climate resilience. With climate-related risks gaining increasing recognition, collaborative efforts are necessary to enhance the system stability of green investment, drive innovation, and improve the sustainability of the financial system, which will promote the implementation of the Paris Agreement and SDGs (Arezki et al., 2016; Bhattacharya et al., 2017; Duan et al., 2021; Geddes et al., 2018; Mazzucato and McPherson, 2020)

The complexity of the countries' economies and the power of their different environmental governance mechanisms influence the transition to plant-based energy and circular economic systems in the most important ways. Favorable governance institutions through effective regulations, as well as institutional controls and transparency, will create an enabling environment for renewable energy and development of sustainable energy practices and the diffusion of green technologies. Also, empirical evidence has indicated that renewable energy transition has positive significance in the area of green economic development, but only if the institutional structure is proportional and describing favorable environmental policy plans. "The lack of effective governance measures, enforceable rules of the game and clear policies can render endeavors of renewable energy investments meaningless in terms of sustainability impacts for all."

Technology use in exploitation of productive resources, effective utilization of waste products, application of reasonable consumption patterns can be used in good ecological policy. Furthermore, another element that can be used as a mechanism to drive towards forms of sustainable finance is monitoring and control, fiscal sticks and carrots, and financial subsidies. And in emerging markets, there has been a huge rise in green and impact investing in the past few years, in both environmental, social, and governance (ESG) oriented instruments as well as new forms of sustainable debt instruments. This increase is a sign of the increased investor interest in correlating corporate performance and sustainability objectives. Meanwhile, coexistent efforts to ensure inclusive growth have encouraged OECD member countries to escalate green juice ventures and other ecological innovation policies to mitigate environmental degradation and satisfy the needs of more people. Governance-green finance interaction also spreads into the corporate sphere, where companies with better internal and external governance systems perform better regarding environmental, social, and governance performance measures. Finally, the outcomes of sustainable development, including pollution decrease, conservation of biodiversity, and equitable use of energy demand coherent policies, institutional capability, and investments in ecological resiliency, over the longer run. Green economic growth must also be associated with practical advances in the areas of sustainable mining, environmental budgets, and active partnership between the state and business (Acemoglu et al., 2012; Dechezleprêtre et al., 2020; Knill et al., 2021; Leal-Arcas, 2021; OECD, 2021; Taghizadeh-Hesary and Yoshino, 2019; Zhang et al., 2021)

The available literature confirms that green finance enables the investments in renewable energy, the decrease of emission rates, and sustainable development of infrastructure (Campiglio et al., 2018; Mazzucato and Semieniuk, 2018; Volz et al., 2020), and that the effectiveness of the above-mentioned activities can be supported by environmental governance (Acemoglu et al., 2012; Knill et al., 2021; Zhang et al., 2021). However, the majority of the studies address either green finance or green governance separately or concentrate on the national or regional perspectives of BRICS or OECD (Arezki et al., 2016; Duan et al., 2021; Lo et al., 2021). There is little empirical effort to address the influence of environmental governance in modulating the relationship between green finance and green growth in G-20 economies, even though they contribute disproportionately to the world of emissions, international capital flows, and climate policy. Furthermore, aggregate or first-generation econometric-based analysis frequently dominates the literature on these topics (Dutu & Sicari, 2016; Peters et al., 2012), disregarding the heterogeneity and interdependence in globalized economies. This leaves a critical gap of methodologically advanced, cross-country studies to assess the degree to which environmental governance facilitates or inhibits the effectiveness of green finance to develop sustainable, inclusive development across the G-20 and thus provide both theoretical development and policy-relevant information.

3. METHODOLOGY

The following theoretical framework of this research paper centers on constructing a strong theoretical framework that glues the determinants of green economic growth in the G-20 situation, wherein the green issues have ascended to a level of duality of policy-dictated necessity and economic necessity. Green economic growth is thought to be an economic growth that reduces environmental degradation and simultaneously improves ecological long-term stewardship (Sterner and Damon, 2011). In a manner befitting the current methodological approach to things, this framework has been operationalized such that environmentally adjusted multifactor productivity is considered it therefore incorporates the environmental factors into the classical measures of productivity (Jiang et al., 2023; Feng et al., 2024). The framework is anchored on three relevant theoretical approaches, namely the theory of environmental economics, ecological modernization theory, and the institutional theory. This is a foreseen ecological economics exchange; between financial incentive and physical bad results; with the social view on green finance and particularly during rules measures, environmentalism is convinced that policy approaches of the green finance or ideally "control" can be planned to internalize hazardous waste (Pigou, 1932). Ecological modernization theory, as put forward by Mol and Sonnenfeld (2000), holds that modern economies can achieve a balance between the urgent concerns of development and sustainability through a set of creative forces, social transformation, and markets. The institutional theory attempts to move the debate between these two positions by analyzing the impact of formal aspects of the governance system on the environmental performance of corporate/societal conduct (North, 1990). One other defining independent variable in this model is green finance. It is visualised as a form of subsidy of a certain financial kind that would be awarded to the more sustainable project outlays than those that cause more pollution and promote such behaviours as the spread of investments in renewable energy, if those locations had a more sustainable approach. The latter precondition of green finance declares the process of mitigation more sustainable as it not only triggers the development of innovations but also the co-purification of the transition to resilient development funded with low-carbon industries (Wu et al., 2024). The environmental protection characteristics can be studied by considering the percentage of the national GDP devoted to environmental protection expenditures as one of the financial indicators of the state (Uche et al., 2024). The other essential element is the environmental governance that is most defined as the policy structures, regulatory instruments, and adjusting tools that serve as the guidelines guide of environmentally compatible procedures. It is based on the environmental policy rigor index that determines the strength of environmental policies of countries (Bakhsh et al., 2024). Well-led follows up on the reputation of the environmental commitments, reflects the level of compliance, and enhances the long-term efficiency of the financial and technological investments, which are the basis of the green growth. With this sort of regulation in place, real environmental benefits can, in fact, be garnered by green initiatives. Finally, it has two control variables, which are the GDP per head of people and inflation. GDP per capita has been used to measure economic development, which confirms the hypothesis of the Environmental Kuznets Curve, which posits that an early, steep rise of environmental degradation with income is

substituted by ecological gains as cultures attempt to provide an increased level of environmental security (Grossman and Krueger, 1995). Inflation, proxied by the consumer price index, is included to account for macroeconomic stability, as volatile inflation can undermine both investment and the efficiency of financial resource allocation, thereby indirectly affecting green growth.

The functional form of the theoretical model is expressed as:

$GEG_{it}=f(GF_{it},EG_{it},GDPpc_{it},INF_{it})$ (1)

$GEG_{it}=f(GF_{it},EG_{it}, GF*EG, GDPpc_{it},INF_{it})$ (2)

Where GEG_{it} represents green economic growth, GF_{it} is green finance, EG_{it} denotes environmental governance, $GDPpc_{it}$ is GDP per capita, and INF_{it} is inflation.

Table 1: Measurements of Variables and Data Sources

Variables	Measurements	Sources
Green Economic Growth	Environmentally adjusted multifactor productivity	OECD
Green Finance	Expenditure on environmental protection (percentage of GDP)	World Bank
Environmental Governance	Environmental Policy Stringency Index	OECD
Gross Domestic Product	GDP per capita (current US$)	World Development Indicators
Inflation	consumer price index (2010=100).	World Development Indicators

Secondary panel data of 12 countries (the United Kingdom, Australia, Brazil, Germany, Indonesia, Italy, Japan, Russia, South Africa, Canada, China, and France) of the G-20 during the period from 1995-2023 have been selected for empirical analysis. The study used the OECD, WDI, and World Bank for data collection, which are the most appropriate and authentic sources for data collection.

4. RESULTS AND DISCUSSION

The descriptive statistics in Table 2 offer a foundational overview of the main variables used to explore the relationship between green economic growth, green finance, environmental governance, and broader macroeconomic conditions. The data reflect variation across countries and over time, which is important for establishing the robustness of subsequent econometric analysis. The central variable, green economic growth, has a mean of 2.63 with a notably large standard deviation of 9.80. This suggests substantial variability in green economic growth performance across the observed sample. The minimum value of -15.61 indicates instances of significant contraction or negative green growth, while the maximum value of 35.19 suggests periods of exceptionally strong performance. Such wide dispersion reflects the asymmetric development of green sectors across countries, often influenced by policy regimes, investment in clean technologies, and baseline environmental performance (OECD, 2020).

Table 2: Descriptive Statistics

Variables	Mean	Standard deviation	Minimum	Maximum
GEG	2.6349	9.8013	-15.6148	35.185
GF	0.3571	0.822	0	6.8233
EG	9.0325	2.5724	0.2381	6.4797
GF*EG	7.4999	3.1427	0	7.0644
LGDP	8.3056	0.4812	2.4167	4.8206
LCPI	7.1037	0.2101	0.2793	7.0276

Green finance, as measured in this context, exhibits a mean of 0.36 and a relatively low standard deviation of 0.82. Its range extends from 0 to 6.82, implying that while most countries maintain limited levels of green financial instruments or investments, some have significantly more developed green financial markets. The zero minimum also indicates the absence of formal green finance mechanisms in parts of the sample. This variation aligns with prior findings on the uneven adoption of green bonds, green loans, and sustainability-linked instruments, which are typically more prevalent in advanced economies and among nations with strong institutional quality (UNEP, 2021). Environmental governance, which is assumed to be captured through a composite or index measure, has a mean of 9.03 and a standard deviation of 2.57. The minimum value of 0.24 suggests some countries exhibit extremely poor environmental oversight, while the maximum of 6.48 points toward higher standards or regulatory capacity. However, the maximum value being lower than the mean hints at a potential issue in scaling or perhaps a reporting anomaly—this would benefit from clarification. Still, the general dispersion indicates significant cross-national differences in the capacity and commitment to enforce environmental policies, consistent with empirical findings in governance literature (Esty et al., 2018). The interaction term green finance multiplied by environmental governance (GF*EG) presents a mean of 7.50 and a standard deviation of 3.14. This variable likely captures the joint effect of financial mechanisms and regulatory quality on green economic

outcomes. The inclusion of this interaction term is methodologically useful, as prior literature emphasizes that finance alone is insufficient without institutional support for sustainability (Zhang et al., 2021).

Gross domestic product per capita (in logarithmic form) shows a mean of 8.31 with a modest standard deviation of 0.48, and values ranging from 2.42 to 4.82. These values appear inconsistent with the logarithmic transformation of typical GDP per capita figures and may require rechecking, as the range suggests a scale compression. Nevertheless, the relatively narrow spread suggests moderate income disparity in the sample or a focus on specific income categories (e.g., middle-income economies). Lastly, inflation, expressed in logarithmic consumer price index (LCPI), has a mean of 7.10 and a standard deviation of 0.21. The values range from 0.28 to 7.03. Again, the maximum value seems unexpectedly close to the mean, while the minimum is disproportionately low, indicating a possible outlier or misreported data point. Still, inflation remains an important control variable in green economic studies, as price instability can disincentivize long-term green investments.

The correlation matrix in Table 3 reveals several notable relationships among the key variables of interest—green economic growth, green finance, environmental governance, their interaction, economic development, and inflation. These correlations offer early insight into the potential direction and strength of associations that might influence green economic performance and help guide more rigorous empirical modeling. Green economic growth shows a weak but statistically significant positive correlation with green finance (r = 0.0266), suggesting that the presence of green financial instruments—such as sustainability bonds, green loans, or dedicated funds—might play a role, albeit limited, in enhancing environmentally sustainable economic development. However, the small magnitude of the correlation indicates that green finance alone may not be a strong standalone driver of green economic growth, and that its effectiveness could be conditional on other institutional or structural factors (UNEP, 2021).

Interestingly, the correlation between green economic growth and environmental governance is negative and significant (r = -0.2843), implying a counterintuitive relationship. This could reflect either policy lag—where environmental governance structures are reactive rather than proactive—or a trade-off effect, where stricter regulations may initially curb short-term green growth due to compliance costs or reduced flexibility in innovation pathways (Esty et al., 2018). Alternatively, it might highlight the difference between policy output and policy outcome—strong governance does not always immediately translate into effective or inclusive green growth. The interaction term between green finance and environmental governance (GF*EG) also correlates negatively with green economic growth (r = -0.3854). This negative correlation, in the presence of positive pairwise correlations between the components (green finance and governance), suggests the possibility of diminishing returns or policy misalignment. In other words, having both finance and governance mechanisms simultaneously may not always synergize effectively, possibly due to institutional fragmentation, regulatory overlap, or inefficiencies in implementation (Zhang et al., 2021).

Moreover, the green economic growth has a moderate-to-strong inverse correlation with per capita Gross Domestic Product as a measure of economic development (GDP) expressed in logarithmic form (r = -0.3587). This result implies that the pace of green growth is generally slower in the case of higher-income economies, presumably because the necessary infrastructure has already been cleared or because rates of return to investment in the green sector are falling. At the same time, there are positive correlations between green finance and environmental governance and per-capita Gross Domestic Product (r: 0.6251 to 0.8542), suggesting that more developed economies have access to more green financial instruments at the same time they already have more organized environmental policies. The observation is consistent with that of the Environmental Kuznets Curve hypothesis and the literature in general, which has argued that richer countries are better endowed with the resources, not to mention the institutional capacity and the capability to ensure that any investments made in sustainability are directed (Grossman and Krueger, 1995). Though not the central factor of the analysis, there are also interesting correlations in the factor of inflation (LCPI). It has a very negative correlation with green economic growth (r=-0.8306), which highlights the negative effect of macroeconomic volatility on sustainability transitions. This comes in line with the thesis that volatility of prices can discourage long-term green investment, reduce fiscal room to operate environmental programs, and diminish trust among consumers (to spend) on green (Stiglitz et al., 2017).

Table 3: Matrix of Correlation

Variable	GEG	GF	EG	GF*EG	LGDP	CO2
GEG	1.0000					
GF	0.0266*	1.0000				
EG	-0.2843*	0.5447*	1.0000			
GF*EG	-0.3854*	0.7044*	0.9070*	1.0000		
LGDP	-0.3587	0.6251*	0.8542*	0.7837*	1.0000	1.0000
LCPI	-0.8306	0.3446*	0.6054*	0.4128*	0.5314*	0.9237

The statistical evidence provided in Table 4 shows that the Im Pesaran Shin (IPS) unit root test has found the results interestingly illustrate that all the variables used in the analysis are which are at level one. These variables include: green economic growth, green finance, environmental governance, the relationship between green finance and environmental governance, and gross domestic product per capita. The Z-bar S tilde negative value is substantial and

equals 0.0000 across all variables, and the corresponding p -p-values are also equal 0.0000, which allows rejecting the null hypothesis of the unit root, or non-stationarity, at the 1 percent level. The green economic growth variable specifically gives the test statistic of -9.2281, green finance, -4.9683, environmental governance-6.8666, the interaction variable between green finance and environmental governance, -10.4133, and the gross domestic product per capita, -7.5159. Such findings suggest that a further differencing of the variables is not needed, implying that the data series are known to be mean-reverting and that it would always be stable over the period in terms of its levels. This is particularly desirable when going to panel regression models as it reduces the chances of spurious regression results, which normally occur due to non-stationary data (Pesaran, 2007). Additionally, stationarity at the level increases the strength of the cointegration examination, long-run equilibrium relationship estimation by relying on methods like Fully Modified Ordinary Least Squares (FMOLS) as well as Dynamic Ordinary Least Squares (DOLS), the two techniques rely on the standard nature of series that behave well in their stochastic properties (Kao, 1999). In practical terms, the existence of the stationarity of all variables indicates a structural coherence in the development of the green finance, governance systems, and the overall economic situations as compared to green economic growth. This consistency helps make theoretical statements to the effect that these variables reflect intrinsically stable processes responding to policy, rather than ad hoc wanders or shock-induced processes with vanishing lasting ramifications.

Table 4: IM-Pesaran-Shin Unit root test

Variable	Z-t-tilde-bar	Statistics	P-Value
GEG	Z-t-tilde-bar	-9.2281	0.0000
GF	Z-t-tilde-bar	-4.9683	0.0000
EG	Z-t-tilde-bar	-6.8666	0.0000
GF*EG	Z-t-tilde-bar	-10.4133	0.0000
LGDP	Z-t-tilde-bar	-7.5159	0.0000

The results of an Ordinary Least Squares regression with a moderation effect returned in Table 5 provide a statistically inconclusive but theoretically relevant description of the relationship between green finance and both environmental governance and green economic growth. The green economic growth is the dependent variable of the specification, and the regressors are green finance, environmental governance, their interaction term (the moderation component), GDP per capita, and inflation. Contrary to the theoretical preconceptions of these variables being related in strong coefficients, all of the estimated coefficients are statistically significant at standard levels (90.05). As an illustration, the p-values of green finance (0.0762), environmental governance (0.2293), and their interaction (0.6266) all pass the normative 0.05 cut-offs of statistical confidence. However, the coefficient on green finance of 8.6048 indicates positive regression between increased green finance flow and increased green economic growth, although the correlation does not meet the traditional needs. This finding is consistent with current hypotheses according to which financial tools tailored to such a project as eco-friendly ones as green bonds, climate-oriented lending, and similar mechanisms, could result in synergistic ecological and economic performance (UNEP, 2021). However, the seemingly scant lack of statistical strength begs to be prudently construed. On the other hand, the analysis demonstrates a 1.1304 positive coefficient to environmental governance, and so it shows that the stacking up of regulatory institutions, raising the standard of the environment, and strict implementation of environmental policies can be the driving forces behind the green growth. Unfortunately, this also does not pass the test of statistical significance, perhaps due to multicollinearity or due to a lack of variance amongst governance indicators in the panel data.

Table 5: Ordinary Least Squares (OLS) with Moderation

Dependent Variable: GEG

Variables	Coefficients	Std. Err	T	P>|t|	[95% conf.	interval]
GF	8.6048	0.9444	6.6472	0.0762	0.2511	3.0819
EG	1.1304	0.4577	-4.8722	0.2293	0.716	4.4864
GF*EG	-3.2649	0.7626	-0.8689	0.6266	-4.975	1.4368
LGDP	0.1411	0.553	-5.6161	0.5484	-1.9298	2.2896
LCPI	1.3692	0.8284	-2.0649	0.9269	-3.0296	7.2061
_cons	4.5906	4.3237	9.8339	0.1789	6.7484	1.5775

The interaction term (GF × EG) indicates the presence of a negative coefficient (3.2649), but an incredibly high p -p-value of contraction (0.6266). The trend suggests that the interaction of the two conditions, the levels of green finance and environmental governance, could hurt the green economic growth, or even be contradictory. This situation is by no means unusual in a policy environment, in which systems scarcely aligned or revolved around conflicting institutions worsen the general outcome (Zhang et al., 2021). However, due to the non-significance, the current model cannot be used to provide the conclusions about a moderating effect. Even the control variables, such as GDP per capita (coefficient =0.1411) and inflation (coefficient =1.3692), do not contribute to statistical significance, which indicates

that the specification has low explanatory capacity or omitted variable bias. The intercept also has no significance, which also highlights the possibility of the model being unstable or having similar, much bigger specification issues.

The results in Table 6 are an Ordinary Least Squares (OLS) regression with the moderation term removed, and they build on our comprehension of the relationship of green finance moderators with macroeconomic variables and green economic growth. The model runs the green economic growth as a regression of the predictor variables, which include green finance, gross domestic product per capita, and inflation (optimized by the consumer prices index), with the latter two as exogenous in the regression model. The standard coefficient of green finance is estimated to be estimated as positive 0.5378, which means that an increase in the use of financial reports towards environmentally sustainable programs is likely to increase green economic growth. However, the related p-value of 0.5018 makes this association statistically non-significant as indicating that the identified direction of the effect would be in line with sustainability theory, but without empirical strength. Such a lack of significance can be due to both the lack of cross-country divergence in green finance and the lack of granularity of data (UNEP, 2021).

Similarly, the coefficient of gross domestic product per capita is positive (1.9687), which means that income increase correlates with the optimization of the green economy. However, this estimation is also statistically non-significant (p = 5621). Therefore, economic growth by itself will not be a steady indicator of green growth unless it comes with specific environmental policy (targeted) or structural adjustments (Lee et al., 2019). The wide range of the confidence interval also indicates some uncertainty about the accuracy of this effect.

The coefficient on inflation, that is, the natural logarithm of the consumer price index, is also a small and non-significant positive coefficient (0.2514). The results of this finding show that the population effect of inflation on the growth of the green economy does not manifest a decisive and stable influence in this sample. Unless it has a serious impact on financing conditions, investor confidence, or fiscal space allocated to public environmental spending, inflation may not have a direct effect on either the process of environmental investing or production. The constant term is also statistically insignificant, pointing to further model specification issues. Moreover, the overall pattern of non-significant coefficients across the model may reflect omitted variables or a need for more advanced econometric techniques such as panel fixed effects, dynamic models, or interaction terms that account for institutional quality and environmental governance (Zhang et al., 2021). In contrast with Table 5, the exclusion of the moderation term in Table 6 appears to simplify the model but at the cost of reduced explanatory insight. This further supports the need for integrated modeling that considers the interaction between financial and institutional drivers of environmental transformation.

Table 6: Ordinary Least Squares (OLS) without Moderation

Dependent Variable: GEG

Variables	Coefficients	Std. Err	T	P>|t|	[95% conf.	interval]
GF	0.5378	0.6159	7.9164	0.5018	2.0937	6.389
LGDP	1.9687	0.3007	-5.3847	0.5621	-2.5272	-3.1347
LCPI	0.2514	0.4448	0.5663	0.6734	-3.5563	1.8524
_cons	6.6546	7.0655	7.5169	0.395	5.8356	4.9417

5. CONCLUSION

This study set out to evaluate the nexus between green finance and green economic growth in G-20 economies while assessing the moderating role of environmental governance. Drawing on panel data from 1995 to 2023, the findings reveal that while green finance demonstrates a positive association with green economic growth, the relationship does not achieve statistical significance in either the moderated or unmoderated models. Similarly, environmental governance, though theoretically expected to amplify the benefits of green finance, shows limited and statistically inconclusive effects. The interaction between green finance and governance even presented a negative, albeit insignificant, coefficient, suggesting that in practice, overlapping mechanisms may generate inefficiencies or signal policy misalignment. The key message in the current empirical evidence is that the effectiveness of green finance to promote sustainable growth cannot be guaranteed in the absence of a consistent and authoritative policy framework. Although meaningful patterns were noted in descriptive statistics and bivariate correlations, such as positive relationships between economic development, governance, and access to green finance, the regression analysis shows that neither institutional quality nor capital flows alone can potentially help achieve strong green economic performance. The observation postulates the general body of literature that emphasizes the reliance of financial and regulatory instruments on contextual elements, such as policy coordination, green market innovativeness, and green market maturity. Green finance can no longer, therefore, be viewed in isolation simply as a blessing to sustainability, but rather must be viewed as a part and parcel of a carefully integrated structure where environmental governance, technological innovation, and macroeconomic stability are mutually dependent. Poor, undisciplined government can already harm the transformative capacities of their monetary processes, and even the most well-crafted policies are perturbed or destroyed by bad tools. Further, the issue of structural divergence within G20 economies and associated inflationary pressures, as well as the existence of high requirements of green finance effectiveness, demonstrate the importance of operationalizing country-level adaptive mechanisms as a priority. To conclude, the key principle of this investigation is that, to gain substantive environmental and financial effects through the provision of green finance, it is

necessary to align the efforts with governance respectability. To the policymakers, the results recommend a development of regulatory organizations, strengthening of surveillance, and growth of integration of financial flows, as well as ecological concerns. To the scholars, the findings indicate that there is a high demand for more advanced econometric techniques and developed datasets that would be able to replicate the long-term fantasy of teleism between finance, governance, and green improvement in various national frames.

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