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Fiscal policy-green growth nexus: Does financial efficiency matter in top carbon emitter economies?

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Abstract

Environmental pollution and climatic change impel economies to discover new methods for sustainable economic development. Green growth is considered an effective way of environmental sustainability. From this perspective, this study evaluates the impact of fiscal policy shocks, financial institutions, and markets development on the green growth of high-polluting economies. The study employed a CS-NARDL approach for investigating the short-run and long-run estimates. The results show that positive shocks in government spending tend to significantly increase green growth in the long-run. In contrast, the negative shock is government spending does not report any significant influence on green growth in the long-run. Financial institution's and financial market's efficiency have a positive impact on green growth in the long-run. Thus, the findings of the study suggest that government spending should be increased with a particular focus on financial markets efficiency and financial institution's efficiency to enhance green growth.

Keyword Fiscal policy shocks · Financial efficiency · Financial institutions and markets · Green growth · Carbon emitter economies · CS-NARDL

Abbreviations

CS-NARDL	Cross-sectional nonlinear ARDL
UN	United Nations
PMG-NARDL	Pooled mean group nonlinear ARDL
CADF	Cross-sectionlly argumented Dickey–Fuller
CIPS	Cross-sectionally augmented Im, Pesaran and Shin

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1 Introduction

In recent years, the pursuit of sustainable development has become a global imperative, with governments and policymakers increasingly recognizing the importance of mitigating climate change and promoting environmentally friendly economic growth (Raihan et al., 2023). This recognition has given rise to the concept of "green growth", which emphasizes the need to reconcile economic prosperity with environmental sustainability. Green growth recognizes the urgent need to address climate change, natural resource depletion, and other environmental challenges while promoting economic prosperity and social well-being (Fay, 2012). Green growth entails shifting from traditional, resource-intensive, and polluting industries toward cleaner and more sustainable alternatives (Han et al., 2022). The concept of green growth emphasizes that environmental preservation and economic development are not mutually exclusive but can be pursued together through innovative policies and technologies. It recognizes that sustainable economic growth is vital for poverty reduction, job creation, and improving living standards, while simultaneously ensuring the conservation of natural resources and the protection of ecosystems (Zhang & Wen, 2008). At its core, green growth involves adopting a holistic approach that integrates environmental considerations into economic decision-making.

The ultimate goal of green growth is to decouple economic growth from environmental degradation. It recognizes that traditional models of development, which often prioritize short-term economic gains at the expense of long-term sustainability, are no longer viable (Edwards, 2021). Green growth seeks to promote a transition toward a more sustainable, inclusive, and resilient economy that respects planetary boundaries and ensures a healthy environment for future generations (Chen et al., 2023). At the heart of the green growth paradigm lies the interplay between fiscal policy and environmental objectives. Fiscal policy has the potential to shape the trajectory of a nation's economic growth and its environmental footprint. By adopting appropriate fiscal measures, governments can incentivize environmentally friendly practices, promote clean technologies, and encourage the transition to a low-carbon economy (Fang & Chang, 2022; Li et al., 2021; Lopez & Palacios, 2014). However, achieving green growth requires more than just the implementation of favorable fiscal policies (Abbas et al., 2022b). Financial efficiency plays a crucial role in facilitating the transition toward a greener economy. It encompasses mechanisms such as green finance, responsible investment practices, and the integration of environmental risks into financial decision-making.

The fiscal policy helps to accumulate and distribute the economic resources of a country. In many countries, a major part of the national income is utilized as government spending and investment. After the 2008 financial crisis, many countries have adopted expansionary fiscal policies to aid and speed up the recovery process, which has influenced various macroeconomic variables and improved the general condition of the economy (Lin & Zhu, 2019). Therefore, many studies have recommended that government consumption is a crucial determinant of environmental quality as well (Islam & López, 2015; Ullah et al., 2021a, 2021b). Although the improvement of environmental quality is not a target of any fiscal policy, nonetheless it is pertinent to examine the role of fiscal policy on environmental standards and pollution emissions because that would help us to detect whether fiscal policy can contribute to green economic growth or not. According to Calbick and Gunton (2014), policy factors alone are enough to explain much of the disparity in emissions between the developed economies. Further, they recognize behavioral choices, which are linked to existing technologies, as the most important determinants of environmental quality (Zhang et al., 2021). As far as government consumption is concerned, countries with a large fiscal sector that have large redistributive capacity can decrease income inequality and increase environmental quality. In a similar type of study, Yuelan (2019) asserted that if the environmental quality is recognized as a luxury public good, its provision will be made possible once the demand for necessary public goods is fulfilled.

However, it is pertinent to mention here that fiscal spending can affect environmental quality either through production-based pollution or consumption-based pollution (McAusland, 2008; Abbasi & Adedoyin, 2021). Once we will identify production and consumption-driven pollution channels it will help to decouple economic growth from carbon emissions. Production-driven pollution can affect the environment through four different channels including income effect, technique effect, scale effect, and composition effect (Abbasi et al., 2021b, 2021c). Large government spending will drive income levels upward which results in demand for better environmental quality by the citizens (income effect). Similarly, higher fiscal spending causes the human capital-oriented activities to drive up which also improves the environmental quality (composition effect). The third channel through which government spending improves environmental quality is improved labor efficiency by increasing the budget of the health and education sector (technique effect). Conversely, higher government spending fosters economic activities which may lead to the degradation of the environment further (Scale effect). On the other side, consumption-driven pollution may also influence environmental quality in either way (Abbasi et al., 2022b). For instance, increased government expenditures in health and education sectors are more like to enhance consumers' current and future income which may spur their consumption activities and ultimately deteriorate environmental quality. However, higher government spending means sophisticated and modernized institutions through improved environmental regulations which may improve the environmental quality (Abbasi et al., 2020; Fullerton & Kim, 2008). These production and consumption channels will help us to decide whether we are heading toward the target of green growth or shying away from it (Abbasi et al., 2021a; Monasterolo & Raberto, 2018).

Just like government spending, financial sector development greatly influence the economies and the progress of a nation is directly linked to the progress of financial sector development. However, the impact of financial sector development on environmental quality is still inconclusive (Leu et al., 2021; Li et al., 2022a, 2022b, 2022c; Sadorsky, 2010). Theoretically, the financial sector development can affect pollution emissions in either way. The detection of such a theoretical link will help us to decide whether financial development can be helpful in decoupling economic growth from greenhouse gas emissions and attaining green growth. As the financial sector develops the provision of funds for investment in green technologies will become easier which is crucial for enhancing green productivity, and consequently achieving green growth (Abbas et al., 2022c; Cao et al., 2022). A well-functioning and vibrant financial sector can help to attain green growth by providing financial support for the implementation of superior environmental practices and standards that can foster economic growth without disturbing the ecological balance of the earth (Zhang et al., 2022a, 2022b). Conversely, the development of the banking sector and stock markets may give rise to manufacturing and industrial activities, which causes economic growth to rise but at the cost of environmental degradation (Jänicke 2012). Similarly, due to banking and stock markets development, the consumers can avail credits from the banks easily, allowing them to buy and consume more energy-intensive products (e.g., automobiles, air conditioners, and other home appliances), a major reason for rising pollution emissions and taking the economy further away from the target of green growth (Ahmed et al., 2022).

In light of the above-mentioned background, the literature exhibits the following research gaps. Firstly, we are unable to find a single study exploring the effect of fiscal policy shock on green growth. The lack of studies exploring the effect of fiscal policy shock on green growth is a notable research gap. Secondly, the empirical literature is silent regarding the impact of financial efficiency on green growth is found. Thirdly, previous literature does not examine the nonlinear impact of fiscal policy shock on green growth. Fourthly, previous studies often relied on outdated estimation methods, which can limit the accuracy and reliability of their findings (Sohail et al., 2022). Many existing studies have explored the determinants of economic growth (Fang & Chang, 2022; Zhang et al., 2021). However, none of the studies has examined the fiscal policy shocks-green growth nexus in the case of top carbon emitter economies. Moreover, none of the studies has examined the nexus between green growth and financial efficiency for the same sample. To fulfill this vacuum, our study explores the effect of fiscal policy shock and financial efficiency on green growth for top polluted economies.

This study makes empirical and theoretical contributions from the following aspects. Our study is the first attempt to explore the impact of fiscal policy shock and financial efficiency on green growth for top polluted economies. The study's theoretical contributions by examining the relationship between financial efficiency and green growth. The examination of nonlinear relationships between fiscal policy and green growth contributes to the development of theoretical frameworks in the field. Therefore, this study has used a newly developed CS-NARDL methodology for empirical tasks and the robustness is confirmed through the nonlinear PMG-NARDL approach. Both approaches help in capturing the impact of positive and negative shocks in fiscal policy shock. This study also contributes to policy formulation by highlighting the relationship between fiscal policy, financial efficiency, and green growth outcomes.

2 Literature review

Policymakers throughout the world strive to adopt maintainable solutions for climatic variations and environmental degradation (Zhang et al., 2022a, 2022b). Fiscal spending on research and development is considered a vital source for the attainment of less polluted green economic growth. Green innovation is a preferable solution to reduce climatic degradation and to ensure green growth. It is mandatory to explore the determinants of green economic growth. One major determinant of green economic growth is the change in fiscal spending (Eyraud et al., 2013). Prevailing literature claims that the composition of fiscal spending is influenced by environmental degradation. However, the nexus between green economic growth and fiscal spending still needs to be explored (Lin & Zhu, 2019). Existing literature supports the contribution of fiscal spending in promoting green economic growth (Zhang et al., 2021). Wang and Yi (2021) denoted that private R&D expenditures are not enough to promote green growth, thus fiscal expenditures are also required. Moreover, the private sector needs fiscal support in the provision of new technologies for the achievement of sustainable green growth (Li & Ullah, 2022).

Afonso and Furceri (2010) denoted that the association between the green economy and the composition of public spending directly influences the implementation of fiscal policy. The literature revealed that the change in composition and level of fiscal spending on research and development enables the economy to enhance its economic growth (Afonso & Jalles, 2012). The targets of green growth can be obtained through living standards and the use of green energy sources (Soundarrajan & Vivek, 2016). Too much dependence on non-renewable energy sources, insufficient fiscal spending in the R&D sector, and unsuitable environmental planning are the major causes behind the failure in the achievement of green economic growth (Fay, 2012; Monasterolo & Raberto, 2018). Environmental pollution and worldwide climatic variations are considered major hurdles in the process of green growth (Fay, 2012; Lin & Zhu, 2019; Yang et al., 2019). According to the United Nations Environment Program (UNEP), green economic growth improves human well-being, while reducing environmental risks (UNEP, 2011).

Fiscal spending is among the key determinants of green economic growth, thus fiscal spending is the main focused variable of the present study. Lopez et al. (2011) denoted that fiscal spending contributes 20 percent to 45 percent of total GDP. Previous studies revealed that the change in level and composition of public spending exert a significant positive impact on green growth and environmental pollution. Additionally, the empirical evidence claims that fiscal policy shocks affect green economic growth (Fayissa & Nsiah, 2013) but very few studies have explored the nexus between public spending and economic growth (Salman et al., 2019). Fiscal spending influences green growth and environmental pollution through the same channel as identified by environmental studies (Lopez et al., 2011 and Wu & Zhou, 2021). Fiscal spending influences green growth through the scale effect which is defined as the increase in fiscal expenditures on public goods that may encourage economic growth that exerts significant pressure on environmental performance thus improving green economic growth. The second channel is described through the composition effect which is explained as the increase in fiscal spending on the education sector may transform the industrial structure into human capital intensive industrial set up that may help in reducing pollution emissions and promotes green economic growth (Dissou et al., 2016). The third channel is described through the technique effect which reveals that fiscal spending on innovation and R&D process may encourage the society to use green technologies such as clean energies and eco-friendly technologies (Ullah et al., 2021a, 2021b). Green technologies can enhance the efficiency of resources during the process of production and reduce the output-pollution ratio (Abbas et al., 2022a; Usman et al., 2021).

Financial development is another major determinant that can cause green economic growth. Several studies have explored the role of financial development in defining environmental performance and green economic growth (Cao et al., 2021). Empirical evidence reports that financial development enhances economic growth but its influence on green economic growth is still not explored adequately (Khan et al., 2021). Financial development promotes green economic growth as it empowers the industrial sector to afford green technologies that are eco-friendly and make little contribution to environmental quality (Adams & Klobodu, 2018). Financial markets development and financial institutions development are major determinants influencing economic development and there exists a close association between economic development, environmental performance, and resource consumption (Yang et al., 2020; Li et al., 2022a, 2022b, 2022c). Empirical evidence also shows that the expansion in size and scale of stock markets and financial institutions causes fluctuations in economic growth and the association between green technologies and financial sector development can mitigate the instability of green economic development (Cao et al., 2021). The studies reported that green finance enhances economic growth through its influence on economic structure, economic efficiency, and eco-friendly environment (Yang et al., 2019). Financial development enhances green growth by promoting the capacity of green credit and promoting green investment, enhancing financial support, stimulating the green finance development, improving the efficiency of resource allocation, optimizing the industrial structure, enhancing the environmental performance, and mitigating the financial friction (Ahmed et al., 2022).

Yang's et al. (2019) study states that financial development, financial markets, and financial institutions can enhance green economic growth. Yang et al. (2019) reported a negative linkage between economic growth and equity market growth in high-income group economies. Bist (2018) tests the relationship between social sustainability, economic growth, and financial development and reported a positive association between economic growth, financial development, and social progress. Likewise, Masoud and Hardaker (2012) investigated the linkage between social progress and financial development for 42 emerging economies and reported a positive relationship between variables. Bayar's (2017) study in the case of emerging countries reported a positive association between financial sector development and green growth. The review of the empirical literature reveals that the previous research focuses on the link between economic growth, public spending, social progress, environmental performance, and financial development but these studies ignore the impact of fiscal policy shocks, financial markets efficiency, and financial institutions efficiency on green economic growth. Thus, our study tries to fill this vacuum in the case of highly polluted economies.

3 Model and method

Fiscal expenditure has now replaced other factors as the main engine of a nation's economic growth. In contrast, King and Levine (1993) included financial-related factors in the endogenous growth framework, demonstrating the favorable effects of a robust financial system on overall efficiency and contributing to economic development. However, financial efficiency may substantially influence environmental performance and green growth (Jensen, 1996) since economic activity is thought to be the primary contributor to carbon footprint and green productivity (Frankel & Romer, 1999). Following the theoretical perspective, our model looks as follows:

$$\mathrm{GG}_{\mathrm{it}} = \eta_0 + \eta_1 \mathrm{GS}_{\mathrm{it}} + \eta_2 \mathrm{FIE}_{\mathrm{it}} + \eta_3 \mathrm{FME}_{\mathrm{it}} + \eta_4 \mathrm{REP}_{\mathrm{it}} + \eta_4 \mathrm{Internet}_{\mathrm{it}} + \varepsilon_{\mathrm{it}} \tag{1}$$

where $\mathrm{GG}_{\mathrm{it}}$ is the green growth which is determined by government spending (GS), financial institutions efficiency (FIE), financial markets efficiency (FME), renewable energy production (REP), internet users (Internet), and μ_{it} is the error term. Increasing fiscal spending may stimulate economic growth by increasing education, R&D, and innovation process, thus an estimate of η_1 is expected to be positive. Financial institutions and markets increase green financial development through green investment and green credit, thus promoting green growth. We anticipate that estimates of η_2 and η_3 will be favorable because financial markets and organizations enhance financial networks and further support green growth. Since this study considers both short- and long-term projections, it differs from the previous research. As a result, the long-run models have been transformed into the framework of error correction:

$$\begin{aligned}\Delta \mathrm{GG}_{\mathrm{it}} =& C_i + \lambda_i\left(\mathrm{GG}_{\mathrm{it}-1} - \beta_i X_{\mathrm{it}-1} - \Upsilon_i C_{\mathrm{it}-1} - \phi_{1i}\overline{\mathrm{GG}}_{t-1} - \delta_2 \overline{X}_{t-1} - \pi_2 \overline{C}_{t-1}\right) \\ &+ \sum_{j=1}^{p-1} \theta_{ij} \Delta \mathrm{GG}_{\mathrm{it}-j} + \sum_{j=0}^{q-1} \eta_{ij} \Delta X_{\mathrm{it}-j} + \sum_{j=0}^{q-1} \tau_{ij} \Delta C_{\mathrm{it}-j} + \eta_{1i} \Delta \overline{\mathrm{GG}}_t \\ &+ \eta_{2i} \Delta \overline{X}_t + \eta_{3i} \Delta \overline{C}_t + \varepsilon_{\mathrm{it}}\end{aligned} \tag{2}$$

The short-run and long-run values of the green growth $\left(\Delta \mathrm{GG}_{\mathrm{it}}\right)$ are generated by the collection of targeted and control regressors denoted by Xit and Cit, correspondingly, the long-run value of the error term is denoted by it. Equation (2) presupposes that public expenditures have equal and opposite impacts on environmentally friendly development. Our primary goal is to adjust Eq. (2) to analyze the asymmetrical impacts of government expenditure on green growth. Following the study of Sohail et al., (2022). we have changed Eq. (2) in the nonlinear framework. This leads to the following two new factors:

$$\mathrm{Pos.GS}_{\mathrm{it}} = \sum_{n=1}^{t} \Delta \mathrm{Pos.GS}_{\mathrm{it}} = \sum_{n=1}^{t} \max\left(\Delta \mathrm{Pos.GS}_{\mathrm{it}},\ 0\right) \tag{3a}$$

$$\mathrm{Neg.GS}_{\mathrm{it}} = \sum_{n=1}^{t} \Delta \mathrm{Neg.GS}_{\mathrm{it}} = \sum_{n=1}^{t} \max\left(\Delta \mathrm{Neg.GS}_{\mathrm{it}},\ 0\right) \tag{3b}$$

where $\mathrm{Pos.GS}_{\mathrm{it}}$ reflects the partial sum of positive changes in government spending, Neg. $\mathrm{GS}_{\mathrm{it}}$ measures the negative shock in government spending. We redesigned the panel nonlinear CS-ARDL Eq. (4) into a new error correction format as follows:

$$\begin{aligned}
\Delta \mathrm{GG}_{\mathrm{it}} = C_i + \lambda_i\big(&\mathrm{GG}_{\mathrm{it}-1} - \alpha_i \mathrm{Pos.GS}_{\mathrm{it}-1} - \beta_i \mathrm{Neg.GS}_{\mathrm{it}-1} - \rho_i \mathrm{FD}_{\mathrm{it}-1} - Y_i C_{i-1} \\
&-\phi_{1i}\overline{\mathrm{GG}}_{t-1} - \phi_i \overline{\mathrm{Pos.GS}}_{t-1} - \eta_i \overline{\mathrm{Neg.GS}}_{i-1} - \varphi_2 \overline{\mathrm{FD}}_{t-1} - \tau_2 \overline{C}_{t-1}\big) \\
&+ \sum_{j=1}^{p-1} \theta_{ij} \Delta \mathrm{GG}_{\mathrm{it}-j} + \sum_{j=0}^{q-1} \delta_{ij} \Delta \mathrm{Pos.GS}_{\mathrm{it}-j} + \sum_{j=0}^{q-1} \pi_{ij} \Delta \mathrm{Neg.GS}_{\mathrm{it}-j} \\
&+ \sum_{j=0}^{q-1} \theta_{ij} \Delta \mathrm{FD}_{\mathrm{it}-j} + \sum_{j=0}^{q-1} \omega_{ij} \Delta C_{\mathrm{it}-j} + \eta_{1i} \Delta \overline{\mathrm{GG}}_t + \eta_{2\mathrm{i}} \Delta \overline{\mathrm{Pos.GS}}_t \\
&+ \eta_{3i} \Delta \overline{\mathrm{Neg.GS}}_t + \eta_{4i} \Delta \overline{\mathrm{FD}}_t + \eta_{5i} \Delta \overline{C}_t + \varepsilon_{\mathrm{it}}
\end{aligned} \tag{4}$$

Cross-sectional dependence has developed as a significant difficulty in the area of panel modeling due to the fact that no country can operate independently in the contemporary era of globalization and that countries are dependent on each other economically and financially. Therefore, if an economic shock in one country impacts surrounding countries, the problem of cross-sectional dependence (CD) in terms of the dynamic panel may develop (Pesaran et al., 2004). As a result, we also completed the CD test created by Pesaran. The second-generation tests are preferred since the first-generation unit root test does not take the CD into account and could mistakenly rule out the null hypothesis. As a consequence, we employed the second-generation CADF and CIPS tests. To avoid the possibility of false regression, we have employed two co-integration tests, namely Kao (1999) and Westerlund (2007). Westerlund provides useful results for CD, structural breakdowns, heteroskedasticity, and serial correlation (2007). Hence, it is superior to other strategies due to the above-stated benefits.

We employed the CS-NARDL framework, a state-of-the-art statistical method for this analysis. Chudik and Pesaran (2015) upgrade and enhance the PMG-NARDL framework using this strategy. The CS-NARDL has a number of benefits over other methods. First, we can obtain both long-term and short-term estimates jointly using this method. Second, this method may also be used to address the variables' integrating properties. So, without conducting a pre-unit root test, we could incorporate the series $I(0)$ and $I(1)$ that are integrated at different orders in the analysis. Third this method addresses the problem of CD (Chudik & Pesaran, 2015). Fourth, even when the slope coefficients are diverse, it can still perform mean group estimates (Chudik et al., 2017). To conclude, this approach works well even with small sample sizes. Although CS-NARDL provides the analytical framework, we also use the PMG-NARDL estimation technique to guarantee the robustness of the results.

3.1 Data

The study intends to scrutinize the impact of fiscal policy shocks, financial institutions, and market developments on green economic growth for high-polluted economies. The study used time-series data from 1991 to 2020. The details about descriptive statistics, definitions, and symbols of variables are given in Table 1. Green growth is a dependent variable. To measure green growth, the study follows Sohail et al. (2022), which measures green growth in terms of environmentally adjusted multifactor productivity. Fiscal policy shock is an independent variable. To measure this variable, the study gets assistance from prior literature. Following Ullah et al. (2020), fiscal policy impact is captured through government spending which is measured by general government final consumption expenditures as percent of GDP. The financial institutions variable is measured as the financial institution's efficiency index (FIE). However, market developments are measured by the financial markets efficiency index (FME). Additionally, the study adopts several control variables. Following the previous trends in literature, the study added renewable energy production and internet as control variables (Li et al., 2022a, 2022b, 2022c; Wei et al., 2022). Renewable energy production is measured as total energy production in quad Btu and internet variables measured as total internet users as percentage of population in this study. The study has collected data from the World Bank, IMF, and the OECD. The mean of GG, GS, FIE, FME, REP, and internet are 4.376%, 15.29%, 0.614%, 0.836%, 6.136% and 32.22%, respectively. The standard deviations of GG, GS, FIE, FME, REP, and internet are 3.752%, 2.848%, 0.136%, 0.217%, 5.806%, and 32.42%.

4 Results and discussion

This is an era of globalization and economies are dependent on each other. Therefore, a shock in an economy also affects other nations as well. Hence, in the recent literature, checking cross-sectional dependence is not just an option but has become mandatory. Following the literature, we have also tested the cross-sectional dependence by applying Pesaran's and Friedman's CD test, confirming cross-sectional dependence in Table 2. Therefore, we have applied CADF and CIPS unit root tests, and the results of both unit root tests are described in Table 3. From Table 3, we can deduce that the variables GG and FME are stationary at $I(0)$ or level in both tests, whereas the remaining variables are stationary at $I(1)$ or first difference.

In the next step, we have checked whether co-integration exists between GG, GS, FIE, FME, GI, and Internet or not. To that end, we have employed two co-integration tests, namely Westerlund's (2007) co-integration test and Kao's (1999) co-integration test. The advantage of using the Westerlund (2007) test is that it can provide correct results in the presence of cross-sectional dependence. Table 4, presents the outcomes of these tests and shows that three out of four of Westerlund's statistics are significant, implying that our

Table 1 Definitions and descriptive

Variables	Definitions	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque–Bera	Probability
GG	Environmentally adjusted multifactor productivity	4.376	4.142	13.14	−6.233	3.752	−0.045	2.78	0.342	0.843
GS	General government final consumption expenditure (% of GDP)	15.29	15.21	21.06	9.802	2.848	−0.199	2.254	4.514	0.101
FIE	Financial institutions efficiency index	0.614	0.631	0.799	0.265	0.136	−0.604	2.554	10.02	0.007
FME	Financial markets efficiency index	0.836	0.977	1	0.28	0.217	−1.144	3.033	31.64	0.000
REP	total energy production from nuclear, renewables, and other (quad Btu)	6.136	3.408	21.37	0.788	5.806	1.163	2.844	32.81	0.000
INTERNET	Individuals using the Internet (% of population)	32.22	18.02	93.18	0	32.42	0.505	1.668	16.88	0.000

Table 2 Cross-sectional dependence tests

	GG	GS	FIE	FME	GI	Internet
Pesaran's test	3.456***	−2.137**	−1.542	5.762***	−2.324**	1.689*
Off-diagonal elements	0.465	0.257	0.295	0.375	0.479	0.405
Friedman's test	31.32***	18.78***	69.32***	12.56***	40.52***	41.02***
Off-diagonal elements	0.175	0.297	0.375	0.479	0.425	0.432

***$p<0.01$; **$p<0.05$; and *$p<0.1$

Table 3 Panel unit root tests

	CADF			CIPS		
	I(0)	*I*(1)		*I*(0)	*I*(1)	
GG	−6.478***		*I*(0)	−3.989		*I*(0)
GS	−1.175	−6.654***	*I*(1)	−1.986	−3.868	*I*(1)
FIE	−1.253	−13.45***	*I*(1)	−1.974	−7.254	*I*(1)
FME	−3.654***		*I*(0)	−3.021**		*I*(0)
GI	1.998	−6.678***	*I*(1)	2.201	−4.032***	*I*(1)
Internet	1.897	−2.135**	*I*(1)	1.325	−2.230**	*I*(1)

***$p<0.01$; **$p<0.05$; and *$p<0.1$

Table 4 Panel cointegration tests

	Westerlund cointegration test				Kao cointegration test
	Gt	Ga	Pt	Pa	
Value	−4.419***	−6.298*	−12.48***	−14.89	−3.245***
Z value	3.410	1.311	6.285	0.196	
P value	0.000	0.095	0.000	0.578	

***$p<0.01$; **$p<0.05$; and *$p<0.1$

variables are co-integrated. Similarly, the statistic of the Kao co-integration test is also significant; hence, both our tests confirm that our variables are co-integrated.

After applying some preliminary tests for the analysis of panel data we next turn our attention to Table 5, which provides the results of the CS-ARDL model. Table 5 provides the estimate of both short and long-run estimates. First, the long-run estimates attached to GS_POS is significant and positive in both CS-ARDL model confirming that a positive shock in government consumption increases green growth-a 1% rise in GS_pos causes the green growth to rise by 1.112% and 1.022%, respectively. Conversely, the estimates of GS_neg are positively insignificant confirming that a decrease in government consumption does not exert any noticeable impact on the green growth. While, the estimate of financial institution's efficiency is positive, implying that a 1% rise in FIE increases the green growth by 1.022%. Another variable that is used to represent is the financial market efficiency, and the estimate attached to FME is positive and significant, signifying that a 1%

Table 5 Nonlinear CS-ARDL estimates of green growth

	Model (1)		Model (2)	
	Coefficient	z-stat	Coefficient	z-stat
Long run				
GS_pos	1.112**	2.151	1.022***	3.154
GS_neg	0.198	0.344	0.354	1.025
FIE	1.022***	2.855		
FME			1.899**	2.214
REP	0.375	1.447	0.723	1.647
Internet	0.177*	1.770	0.402**	1.967
Short-run				
GS_pos	0.517	0.442	0.434*	1.867
GS_neg	0.632	0.618	0.365	0.588
FIE	1.210***	3.187		
FME			1.019	0.378
REP	1.081	0.487	0.356	1.010
Internet	0.307	1.087	0.689	0.985
ECM(−1)	−0.652**	2.366	−0.601***	2.698

***$p<0.01$; **$p<0.05$; and *$p<0.1$

rise in the efficiency of the financial market causes the green growth to rise by 1.899%. The estimates of renewable energy production are insignificant in both models; whereas, the estimates of the Internet are significantly positive in both models. Quantitatively, a 1% rise in the number of Internet users increases green growth by 0.177% and 0.402%. The long-run estimates are valid depending on the significant and estimates attached to $ECM_{t-1.}$ In the short run, the estimates are insignificant for most of the variables.

Table 6 provides the results of PMG-ARDL model which confirm the robustness of our analysis. The estimate attached to GS_POS is significantly positive in both models, implying that a 1% rise in government consumption improves the green growth by 1.098% and 1.273%, respectively. Just like baseline models, the estimated coefficients of GS_NEG are insignificant in both models. The estimate attached to FIE is positive and significant, suggesting that a 1% rise in the efficiency of financial institutions causes the green growth to rise by 1.066%. Likewise, a 1% increase in FME causes the green growth to rise by 1.422%. Unlike, the basic model, the estimates of REP are positive in both models. More specifically, an increase in renewable and nuclear energy production by 1% improves the green growth by 0.278% and 0.050%, correspondingly. Lastly, the estimated coefficients of the Internet are significant and positive in both models and the size of estimates are 0.062% and 0.015% in the first and second models, respectively. Just like baseline models, in the robust model, the estimates attached to ECM_{t-1} are significantly negative, a sign of co-integration among the variables. In the short run, the positive shock in government consumption improves green growth and the short-run estimates of negative shocks are insignificant. The short-run estimates of ΔFIE and ΔFME are significantly positive, whereas other short-run estimates are insignificant.

Our results imply that government spending positively contributes to green growth. Fiscal policy is considered a crucial factor in the collection and distribution of a country's economic resources (López et al., 2011). During the years 2010–2012, government spending, on average contributes to 25% of the GDP in developing economies (World

Table 6 Nonlinear ARDL-PMG estimates of green growth (Robustness)

	Model (1)		Model (2)	
	Coefficient	t-Stat	Coefficient	t-Stat
Long-run				
GS_POS	1.098***	8.101	1.273***	3.750
GS_NEG	0.515	1.429	0.960	1.480
FIE	1.066**	2.058		
FME			1.422**	2.339
REP	0.278***	3.802	0.050***	2.627
INTERNET	0.062***	2.911	0.015**	2.268
Short-run				
D(GS_POS)	1.842***	4.190	1.280***	5.255
D[GS_POS(−1)]	1.012**	2.563	1.179**	2.234
D(GS_NEG)	0.265	0.288	0.762	0.835
D[GS_NEG(−1)]	0.303	1.212	0.472	1.558
D(FIE)	1.575**	2.055		
D[FIE(−1)]	0.805	0.635		
D(FME)			1.181*	1.810
D[FME(−1)]			1.141***	4.589
D(REP)	1.206	1.290	1.679	1.172
D[REP(−1)]	0.573	1.412	2.330	1.263
D(INTERNET)	0.154	1.481	0.036	0.547
D[INTERNET(−1)]	0.251	1.194	0.157	1.368
C	3.810*	1.708	3.217**	2.217
Diagnostics				
ECM(−1)	−0.693***	2.585	−0.547***	4.206
Hausman-test	1.023		0.369	

***$p < 0.01$; **$p < 0.05$; and *$p < 0.1$

Bank, 2015); hence, government expenditures can play an important role in fostering the economic growth of nations. As economic activities are considered to be the major determinant of environmental quality; therefore, government spending can also influence environmental quality (Lopez & Palacios, 2014; Halkos & Paizanos, 2013). As a result, government spending and R&D activities increase green innovation in the economy, which are essential to achieve green growth. Our study produces a positive nexus between fiscal policy shock and green growth. This finding is supported by various arguments. Studies argue that fiscal policy plays a fundamental role in addressing global transition and challenges toward the green economy (Lin & Zhu, 2019). Through proper alignment of government expenditures and revenues, then fiscal policy creates a green investment that increases green growth. Some studies justified this relationship as the fiscal policy uses government spending to address various environmental challenges such as pollution, climate change, biodiversity, and congestion that consequently improves green growth (Zhang et al., 2021). Moreover, fiscal policy aligns government spending with environmental challenges that enhance the effectiveness of the fiscal policy. The study of Wong et al. (2022) inferred that increased government spending increases investments in green infrastructure, such as renewable energy projects, public transportation systems, energy-efficient buildings, and waste management facilities. These investments not only stimulate economic activity but also promote the development and adoption of clean technologies. Moreover, government spending also influences consumer behavior and stimulate demand for green products and services. Through public procurement policies, governments prioritize purchasing environmentally friendly goods and services, which creates a market for green businesses and encourages their growth. This increased demand leads to economies of scale, lower production costs, and broader adoption of green practices, contributing to green growth (Mahmood et al., 2022).

Likewise, improved efficiency in the financial sector has a strong positive association with economic growth (Le et al., 2019). Conversely, the link between financial sector development and environmental quality is still not clear (Li et al., 2022a, 2022b, 2022c; Sadorsky, 2010). Improving the efficiency of financial institutions and markets enable the majority of people, individuals, and businessmen, to acquire and access a wide variety of financial services, making investment in green technology easy and feasible. Efficient and well-functional financial institutions and markets can help to green activities by providing convenient, affordable, and reliable financial services which are crucial for fostering research and development activities and producing green products. Therefore, increased provision of funds, due to the efficiency of financial structure, to green production and manufacturing activities helps the economy to attain green growth at a greater speed. In support of our findings, studies argue that financial efficiency plays a fundamental role in supporting economies in adopting climate change measures and enhancing their resilience to environmental risks (Ahmed et al., 2022). Financial efficiency helps in reducing climate sustainability-related risks and mitigating the intensity of these risks. Cao et al. (2022) denoted that financial sector policies help in determining the level of investment that promotes green growth. Additionally, financial efficiency ensures the sustainable and efficient channeling of funds for green growth. Hafeez et al. (2022) reported that financial efficiency contributes significantly to achieving green growth and ensuring transition in resource utilization. Alsagr (2023) described that financial efficiency plays a crucial role in mobilizing capital toward green investments. Efficient financial systems facilitate the flow of funds from savers and investors to green projects and environmentally friendly businesses. By efficiently allocating financial resources, financial institutions direct capital toward renewable energy projects, sustainable infrastructure, and eco-friendly technologies. This increased funding supports the expansion of the green sector, stimulates innovation, and drives green growth. Additionally, financial efficiency helps lower the cost of capital for green investments. When the cost of capital is reduced, it becomes more affordable for businesses and individuals to invest in green projects and technologies. This, in turn, encourages greater adoption of sustainable practices, promotes green entrepreneurship, and facilitates the scaling up of green initiatives, leading to increased green growth (Lv et al., 2021).

5 Conclusion and policy implications

Green growth is imperative to obtain sustainable development. Previous studies have explored the nexus between fiscal policy shocks and carbon emissions, but overlooked the effect of fiscal policy shocks on green growth. The prior studies have not incorporated the role of financial institutions and market development in the determination of green growth. Hence, this study purposes to explore this thought-provoking topic. The study examines the impact of government spending, financial institution's efficiency, and financial market efficiency on green growth for highly polluted economies from the period 1991 to 2020. The study employs a CS-NARDL approach for empirical investigation. The following findings have been obtained from empirical analysis. In the long-term, the results disclose that positive shocks in government spending have a positive effect on green growth, but the negative shocks in government spending have an insignificant effect on green growth. Additionally, financial institution's efficiency and financial market's efficiency result in increasing green growth in the long-run. Renewable energy demand reports no contribution in defining green growth. However, internet development positively improves green growth in the long-run. In the short-run, positive shocks in government spending has a positive impact on green growth. However, negative shock in government spending has insignificant impact on green growth in the short-run. Financial institution's efficiency brings a positive increase in green growth in the short run. But financial market efficiency, renewable energy production, and internet utilization have insignificant influence on green growth in the short run.

Our study presents the following policy implications on the basis of the findings. There is a need to reallocate the fiscal spending specifically to the education sector and research and development sector which can result in enhancing green economic growth significantly. The high-polluted economies should allocate funds to the industrial sector for the development of green technologies and the outcomes of this public spending must be governed very strictly. Such policies should be formulated that include strategies for technological transformation, consumption and production systems and infrastructures, lifestyle, behavior, consumption, and technological choices. There is a need to understand the power of markets development and financial institutions in order to enhance environmental performance and ensure green economic growth in highly polluted economies. To achieve the objective of reducing pollution; the governments of highly polluted economies should promote investment in the renewable energy production sector. The financial institutions and markets should evaluate the remunerations of the bonds market for providing funds for the development of clean energy and green technology. Since government spending promotes green growth, prudent fiscal management can play a vital role in mitigating the environmental impact of economic growth. Fiscal management through improved financial efficiency can help allocate spending more pragmatically to achieve sustainability of environmental and economic objectives. Moreover, on the government front, we suggest raising the proportion of government current spending in the overall category of government expenditures. Consequently, expanding public spending in public and social areas, including healthcare, schooling, environmental conservation, and other significant social sectors, is essential. This would raise the government portion of current spending relative to overall state spending and help decouple economic growth and environmental degradation.

Despite providing helpful policy implications, this research contains various limitations as well. In our study, fiscal policy shock impact is measured through government spending. The revenue side is not included in our analysis, despite the fact; revenues are a fundamental tool of fiscal policy shock. Future studies should capture fiscal policy shock impact through government revenues. Moreover, future studies should examine the simultaneous impact of revenue and expenditure shock on green growth. One key limitation of this study is that the analyses are done at an aggregated level. To the best of our knowledge, the influence of fiscal policy shocks and financial efficiency on green economic growth has not been explored at an economy-specific level. The economy-specific level analysis can be done for highly polluted economies in future research. A similar empirical analysis can be performed for other nations in upcoming research. Future research can be extended by including the impact of digital financial inclusion on green economic growth for highly polluted economies.

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Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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