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Do economic complexity and trade diversification promote green growth in the BRICTS region? Evidence from advanced panel estimations

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ABSTRACT

Green growth is a comprehensive and integrated approach that ensures the potential economic deliverables of the natural capital on a sustainable basis. Existing studies have explored various deriving factors of green growth. However, none of the studies has evaluated the combined effect of economic complexity, trade diversification, renewable energy consumption, and environment-related taxes to promote green growth. Therefore, this study quantified the impact of these variables on achieving green growth goals for BRICTS countries (Brazil, Russian Federation, India, China, Turkey, and South Africa) from 1995 to 2018. The study addressed the potential econometric issues of panel data, such as cross-section dependency, slope heterogeneity, data nonstationary through robust testing. Cross-Sectional ARDL has been applied to investigate the long-run and short-run association among the study variables. The findings suggest that economic complexity, trade diversification, renewable energy consumption, and environment-related taxes significantly drive green growth in BRICTS countries. However, their marginal contribution substantially varied. Similar results are endorsed using alternative estimators and offer pertinent policy implications.

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Green growth; economic complexity; trade diversification; renewable energy; environment-related taxes

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1. Introduction

In the era of industrialization with rapid economic growth, sustainable development is the key agenda (Kwilinski et al., 2019). Economic growth is important for improving the quality of life, reducing poverty and inequalities, and enhancing overall prosperity (Saleem et al., 2022). However, economic growth has environmental consequences, such as excessive greenhouse gas (GHG) emissions, global warming, waste production, environmental degradation, and biodiversity losses (Hao et al., 2021). Environmental protection has become a major concern for policymakers. Due

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to the frequent economic transformations, the structural growth toward sustainability is no longer effective (Rubbo et al., 2021). Therefore, there is a need to adopt the alternative economic growth path, such as green growth, which is geared toward efficiently consuming economic resources, mitigating the environmental impact, and meeting sustainable development goals (SDGs-13). The concept of green growth was raised as an alternative perspective of economic growth by considering the potential social, economic, and environmental constraints for sustainable development (Tawiah et al., 2021). According to the (OECD., 2018), 'green growth means fostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies' Green growth is also known as 'the environmentally adjusted multifactor productivity growth' (Hao et al., 2021).

The additional component to measure green growth other than the traditional GDP measures is the resource consumption costs (the cost of environmental impact). The achievement of green growth goals is subject to the development and diffusion of environmental-friendly technology and products and other economic factors. Existing studies have explored various sets of factors that drive green growth. For instance, economic complexity is important in determining the products' skills, knowledge, diversity, and ubiquity needed for green growth. Similarly, trade diversification also enhances economic growth by exploring new markets and business opportunities (Can et al., 2021; Sun et al., 2022). Renewable energy consumption is the major component of the sustainable development function. Besides this, the environment-related tax is the carbon-pricing strategy to control the GHGs emission and support resource management to achieve green growth (Hao et al., 2021). However, the combined effect of economic complexity, trade diversification, renewable energy consumption, and environment-related taxes to promote green growth has not been explored yet. Therefore, to cover the gap, this study quantified the impact of these variables on achieving green growth goals for emerging economies of BRICTS countries (Brazil, Russian Federation, India, China, Turkey, and South Africa).

BRICTS countries are the unique economic bloc of emerging economies (middle-income group countries) with steady growth and are acknowledged as the fifth largest group in the world economy. This bloc has achieved a remarkable rise in GDP in recent decades. Therefore, BRICTS countries are a key driver of global economic growth because their aggregate GDP is comparatively higher than G7 countries. The massive production activities and high population has extensively enhanced energy consumption. BRICTS are accountable for consuming more than 40% of the world's total energy consumption, leading to high carbon emissions. BRICTS countries are also blamed for being the top GHGs emitters in the world (Caglar et al., 2022). Besides this, these countries have enhanced a considerable share in global trade (import and export merchandise goods). China is a key player in importing and exporting merchandise goods and services, followed by Russia and Brazil. However, India has also contributed to importing and exporting services (Z. Zhang et al., 2019). Emerging economies like BRICTS face multiple economic and environmental challenges to sustainable development. Green growth has become the strategic priority of emerging economies (Mealy & Teytelboym, 2022). Green Growth Index is a

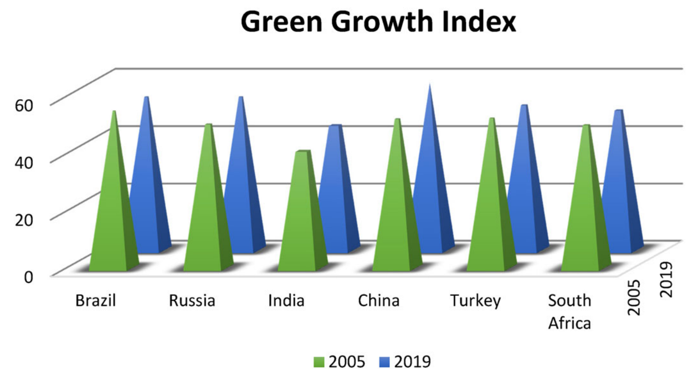

Figure 1. Green growth Index – comparison of 2005 and 2019 index values of BRICTS countries.
Source: https://greengrowthindex.gggi.org/wp-content/uploads/2021/01/2020-Green-Growth-Index.pdf

'composite index measuring a country's performance in achieving sustainability targets, including Sustainable Development Goals (SDGs)' (Acosta et al., 2020). Figure 1 demonstrates the improvement of BRICTS countries in the green growth index from 2005 to 2019. These countries fall under moderate progress (40% to 60%) toward achieving sustainable goals. According to the data (GGGI, 2021), China has shown the highest progress in the study bloc, from 52.07 in 2005 to 58.33 in 2019. At the same time, India remains on the same ranking as the group of Asian countries against the progress for sustainable development. In comparison, South Africa is the only country with a decline in progress from 49.96 in 2005 to 48.79 in 2019.

Economic complexity is the degree of complexity that highlights and evaluates the industrial system differences, productive structure evolution, and trade partners (Adebayo et al., 2022) to obtain green growth. It estimates the available knowledge of the economy and forecasts future economic growth. Economic complexity accelerates sustainable economic efficiency and expertise by improving the production process, increasing economies of scale, reducing production costs by applying the specialized division of labor, and providing knowledge and technology (F. Wang et al., 2021). Moreover, it is the way to transform the economy from an energy-intensive to a technology-intensive economy. Therefore, one of the important measuring tools of economic growth or the country's productive capacity is the economic complexity index (ECI). The ECI has first introduced by (Hidalgo & Hausmann, 2009) to measure the export capabilities required for sustainable economic growth. This index determines the products' skills, knowledge, diversity, and ubiquity. It states that economically grown and developed countries have a high ranking of ECI due to complex and diversified export products (Caglar et al., 2022). Figure 2 shows the ECI for BRICTS countries. Among all these countries, the highest index value has been obtained by China, which exhibits the strong, productive capabilities of the country with a complex export portfolio. At the same time, turkey and India illustrate steady growth for a few decades. While for South Africa, a significant decline has been observed since 2014.

Similarly, another important factor highly influences green economic growth is trade diversification. Existing studies have proven that trade plays a vital role in economic sustainability (Can et al., 2021). Trade with high export portfolio boosts

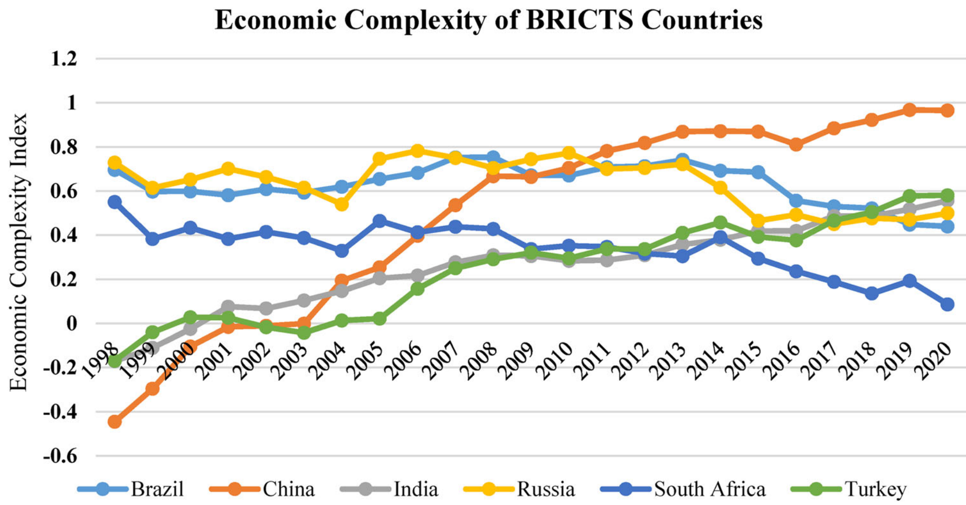

Figure 2. Economic Complexity Index ranking of BRICTS Countries.
Source: Country Rankings (ECI) | OEC - The Observatory of Economic Complexity https://oec.world/en/rankings/eci/hs6/hs96

economic growth. It upsurges the per capita GDP, reduces poverty and unemployment, and supports the well-being of society. However, at the same time, carbon-intense merchandise trading and manufacturing enhance environmental degradation (Jiang et al., 2022) and creates hurdles to achieving green growth. Therefore, it has been suggested by World Bank and International Monitoring Fund (IMF) to divert the trade portfolio. Trade diversification (TRD) is 'the process by which a business, nation, or other economic entity offers a range of products or services instead of specializing in just one'. TRD has various advantages. For instance, it prevents the economy and entrepreneurs from global trade shocks and unforeseen unfavorable circumstances (Song et al., 2021). It provides more business opportunities by exploring new markets (Can et al., 2021). This study uses trade diversification as the combined proxy of import and export diversification. The TRD is the compositional change in the import and export basket where the export specialization and concentration have reduced, and the number of different products has increased and decreased the dependency risk on the specialized products (Saleem et al., 2022). At the same time, import diversification promotes spending on distinct exporters. Countries with high-tech imports enhance economic growth (Mania & Rieber, 2019). However, some studies have highlighted the inverse U-shaped relationship between export diversification and green growth based on the threshold level of economic growth (Munir & Javed, 2018). Trade diversification has been measured through the trade diversification index, which 'signals whether the structure of exports by-product of a given country or group of countries differs from the structure of the product of the world'. Figure 3 demonstrates the TRD index values for BRICTS countries.

It is widely known that energy consumption is the primary contributor to economic growth; however, for sustainable economic growth, the role of renewable energy (RENR) is inevitable. Many studies (Sohag et al., 2021; Usman et al., 2021; W. Zhang et al., 2022; Y. Wang et al., 2020) have suggested RENR as a substitute for

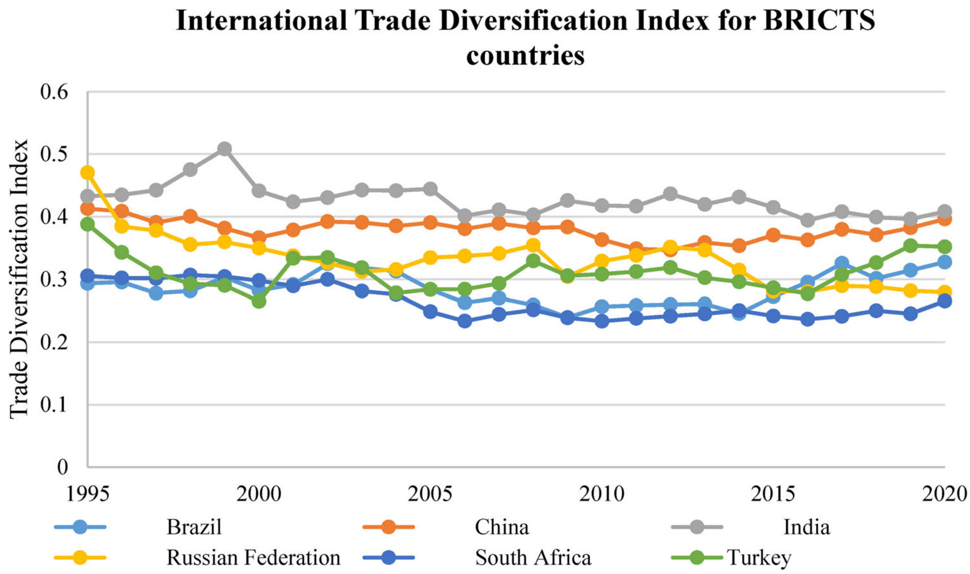

Figure 3. International Trade Diversification Index of BRICTST countries.
Source: https://unctadstat.unctad.org/wds/TableViewer/dimView.aspx

fossil fuels. Therefore, the consumption of renewable energy (RENE) is conducive to achieving green growth targets. These resources are cost-effective and more efficient with green innovation (Chen et al., 2021; J. Hu et al., 2022), reduce externalities, and become a driving force for green growth and economic prosperity (Usman et al., 2021). Similarly, for the sustainable development goal (green growth) , the most important objective is determining the routes toward economic growth without paying environmental costs. Therefore, governments and policymakers are taking serious initiatives to control environmental degradation due to economic growth. They imposed carbon pricing in the form of taxes as the effective policy instrument on the consumption of fossil fuels due to their high carbon intensity. These taxes are called environment-related taxes. Numerous studies are agreed on implementing the ERT to promote RENR consumption to reduce carbon intensity and accelerate green growth (Ahmad et al., 2021; Doğan et al., 2022; Fan et al., 2019; Klymenko, 2019; Spinesi, 2022) Also, to take the maximum benefits and to promote the consumption of renewable energy these environment-related taxes used as the subsidies to enhance green growth (Hao et al., 2021).

The most critical part of the research paper is the selection of appropriate methodology to obtain reliable outcomes. Following the existing studies (Hao et al., 2021; Tao et al., 2021), this study applied the advanced panel data estimator of 'cross-sectionally augmented autoregressive distributed lags CS-ARDL' to evaluate the impact of economic complexity, trade diversification, renewable energy consumption and environment-related taxes on green growth of BRICTS countries from 19950to 2018. The study prefers the CS-ARDL analysis estimator to avoid biased results by addressing all the econometric issues which may manipulate the original outcomes. As the prerequisite to running CS-ARDL, this study has applied Pesaran (2015) test for cross-section dependency, Pesaran (2007) and Bai & Carrion-I-Silvestre (2009) test for the unit root of variables data series, while Pesaran and Yamagata (2008) test used to determine the slope heterogeneity. Consequently, to confirm the cointegration among variables (Westerlund & Edgerton, 2008) and (Banerjee & Carrion-I-Silvestre, 2017) has applied. After having the short-run and long-run estimates to disclose the variable relationship, the study employed the 'Augmented Mean Group' (AGM) and 'Common Correlated Effect Mean Group' (CCEMG) to endorse the estimation. The study's findings revealed that all the independent variables such as economic complexity, trade diversification, renewable energy consumption and environment related taxed significantly contribute to promote the green growth in the BRICTS countries.

The rest of the research is constituted as follows: Section two discusses the empirical evidence from the existing literature for each independent variable, such as economic complexity, trade diversification, renewable energy, and environment-related taxes relationship with green growth. Subsequently, the third section of the methodology provides the theoretical background of the association among study variables. In addition, this section also shares the data summary and its sources and suggests a suitable methodology for the analysis. Section four gives a detailed discussion of the test results applied in the analysis; the last section of the conclusion summarizes the study and suggests some policy recommendations to achieve green growth.

2. Literature review

2.1. Economic complexity and green growth

In recent years various studies have used economic complexity as the major strategy to promote social, economic, and environmentally sustainable growth. Regarding economic sustainability, this study reviews the existing studies to investigate the influence of economic complexity on green growth. Economic complexity is the country's productive capabilities and competitive advantages measured by the ECI (Economic Complexity Index)(Hausmann et al., 2014). The economic Complexity Index ranks the countries based on their export portfolio similarities. The high index value of ECI illustrates that the country has high economic growth, expertise, and efficiency, and the export basket is composed of technologically sophisticated products. In contrast, the low level of ECI shows that the countries' economic growth is not considerable, and the greenhouse gas emission is high due to the export of technologically unsophisticated products (Mealy & Teytelboym, 2022). The existing literature on the relationship between ECI and green growth is scant. However, numerous studies have discussed the effect of ECI on other major components of economic development. Such as (Sepehrdoust et al., 2022) highlight income inequalities as a critical factor of economic growth and investigate the economic complexity role in income inequality in developing countries from 2000 to 2019. They found that economic complexity increases income inequality and promotes economic growth.

Some studies discuss the EC's influence on regional economic growth. For instance, (F. Wang et al., 2021) refer to economic complexity as the economic capabilities in resource allocation, knowledge application, and industrial chain expansion. While evaluating the impact of EC on the green development efficiency of various provinces of China, they suggested that ECI has positively associated with the green development of China provinces. It has been witnessed in two ways; for instance, EC directly accelerates green economic growth. Similarly, improving the human capital and innovation levels is mediating in improving the ECI impact on green economic development efficiency. Likewise, a study by (Gao & Zhou, 2018) assessed the role of the provisional economic complexity of china by accommodating the firm-based data of 25 years. They found that the ECI significantly correlated with economic development and income inequalities. Moving toward the green economy (Mealy & Teytelboym, 2022) measures economic complexity's productive capabilities to obtain green economic growth. They assign ranks to the countries based on the complex green product exports. The study explored that the high economic complexity provides a strong path to green growth by reducing carbon emissions and transforming traditional industrialization toward green industrialization. In addition, (Fraccascia et al., 2018) discussed the economic complexity regarding green products production and comparative capabilities to improve the exports of green products for the sample of 41 countries from 2005 to 2013. Similarly, (Dordmond et al., 2021) determined the relationship between economic complexity and green job creation for 27 states of Brazil and found that economic complexity promotes green employment.

2.2. Trade diversification and green growth

Trade plays a vital role in promoting economic growth. There are a plethora of studies discussing the volume-based trade nexus with economic growth. However, the link between compositions-based trade in trade diversification and green growth has not been significantly explored. For instance, few studies (Saleem et al., 2022) have investigated export diversification's impact on attaining green growth targets in SAARC 'The South Asian Association for Regional Cooperation' countries from 2000 to 2019. They found that export diversification has an inverse and insignificant relationship with green growth. It means that the SAARC country's exports are concentrated; therefore, these countries cannot reap the benefits of export diversification and energy efficiency production techniques to improve green growth. Other studies have linked trade diversification (proxy of export and import diversification) with different forms of economic development, such as (Charles et al., 2018) determined the export diversification linkage with the economic growth of Nigeria from 1981. Their study explored that export diversification enhances economic growth in Nigeria's early years of analysis. Whereas in the last period, the upsurge in economic growth is due to the oil export only, while the export diversification significantly declines the economic growth due to the weak institutional quality. Therefore, the product specialization strategy gives better output than the export diversification.

Likewise, (Carrasco & Tovar-García, 2021) examines the accumulated role of three important factors, export diversification, import composition, and export composition, on trade-based economic growth. The outcome of their study revealed the insignificant influence of export diversification and export composition on the economic growth of 19 developing countries. In contrast, the import composition significantly enhances the economic growth due to the high share of high-tech imports (Mania & Rieber, 2019) highlight the productive capabilities in the export diversification to attain sustainable economic growth targets by applying the advanced panel data estimations on the three samples of developing countries from Latin America, Sub-Sahara Africa, and Asia from 1995 to 2015. They discovered that export diversification with technology spillover accelerates economic growth with the help of technology spillover. They argue that the quality of the export diversification matters concerning the country's structural and productive capacity. The emerging markets and developing countries (Trinh & Thuy, 2021) evaluated the association between export diversification and economic growth. They found that at or above the certain regression threshold, the export diversification amplifies the economic growth, while below the threshold level, the impact of export diversification becomes insignificant on the economic growth of sample emerging markets and developing countries.

In contrast, below a certain level of economic. Similar outcomes have already been explored by (Munir & Javed, 2018), who investigated the impact of export diversification (vertical and horizontal) on economic growth in four countries in South Asia. Bangladesh, India, Pakistan, and Sir Lanka. The outcome of their study shows the inverse U-shaped relationship between these variables, which means that in the initial years of economic development, export diversification boots the economic growth. However, after some threshold level, the export diversification influence becomes insignificant while the export specialization enhances sustainable economic growth.

2.3. Renewable energy and green growth

The attainment of green growth targets is highly reliant on energy resource consumption in the green total factor productivity. However, high consumption of fossil fuels apricate production and boosts the economy, consequently increasing carbon intensity. Various studies have highlighted the key conduits to control carbon emissions. Renewable energy consumption is an extensively reported solution to reduce carbon intensity and obtain sustainable economic growth. The nexus analysis between renewable energy and green growth (economic growth) has obtained two different conclusions. One group of the study conclude that as a substitute for fossil fuels, the consumption of renewable energy (RENE) is conducive to achieving green growth targets. For instance (W. Zhang et al., 2022) investigated the impact of RENE on the sustainable economic growth of 34 countries for the period from 2007 to 2017. The RENE accelerates sustainable economic growth as an alternative energy source by improving product quality and energy efficiency. However, the enhanced economic growth is subject to a certain threshold limit of RENE. Likewise, (Sohag et al., 2021) also affirm the positive association between RENE and green growth (GGR) in OECD countries. They employ the CS-ARDL method and found that RENE's biomass or non-biomass types boost GGR. They consider it an important means of energy conversation to achieve sustainable economic development.

In addition, (Usman et al., 2021) selected 15 top GHGs emitting countries to study the impact of renewable energy on ecological footprint and economic growth. They found RENE highly effective in boosting economic growth in the study period from 1990 to 2017. Besides this, (Y. Wang et al., 2020) define the RENE as a crucial strategic step toward achieving the regional economic sustainability of China. Similarly, (Tawiah et al., 2021) investigate various determinants to achieve the sustainable development goal of 2030 set by 123 countries categorized as developing and developed. RENE's energy-related factor was found to positively impact green growth along with other constructive factors. On the other hand, another group of studies revealed an insignificant association between RENE and GGR. For instance, A study on top oil-producing countries of Africa by (İnal et al., 2022) tested the role of RENE on the economic growth of the sample countries by applying the bootstrap panel cointegration test. The analysis concludes that the RENE do not facilitate economic growth due to the underutilization of their potential consumption of RENE. For E7 countries (Aydoğan & Vardar, 2020) found that RENE has a negative impact on the real GDP from 1990 to 2014. They argue that implementing RENE has to bear some economic cost; therefore, consumption of RENE slows economic growth in emerging economies. These results endorsed the findings of (Qi & Li, 2017), who argue that the RENE has a negative impact on economic growth for EU countries because the EU countries belong to the high subsidy group of economies whose threshold regime is not appropriate for RENE.

2.4. Environment-related taxes and green growth

Existing literature has several studies highlighting the role of environment-related taxes in mitigating carbon emissions, while the correlation between environment-related taxes and economic growth has not drawn much attention. According to recent studies (Tao et al., 2021), environment-related taxes theory suggests that the ERT strategy discourages the consumption of carbon-intensive energy resources for production activities. Therefore, the economy has to withdraw from the steady growth, whereas some studies suggest a contradictory relation between ERT and GGR. Supporting the positive influence (Ahmad et al., 2021) compare two countries, China and India, for the imposition and collection of ERT to retain sustainable economic growth. They posit that ERT significantly constructive sustainable economic growth in both countries. A recent study by (Spinesi, 2022) studies the correlation of ERT on income inequality, economic growth, and human capital for the US economy. They found that the ERT in terms of carbon pricing is more effective and enhances income inequalities due to an improved per capita growth rate. Thus, ERT boosts sustainable economic growth in the R&D-driven growth model.

In addition, (Fan et al., 2019) analyzed the environmental taxes' role in green development. The study used the new dynamic system of four dimensions for China. They explore that the imposition of environmental taxes enhances government control to reduce carbon intensity. Moreover, ERT also helps the government adopt advanced technology and create consumer awareness for better resource management. Hence the ERT plays a constructive role in attaining economic growth. (Hao et al., 2021) use the sample of G7 countries to evaluate the environment-related multifactor economic growth and confirm the carbon curtail role of renewable energy in supporting green growth. Similarly, (Klymenko, 2019) conducted a study to confirm the role of environmental taxes as a good policy instrument to obtain green growth in the EU and Ukraine. Since sustainable economic growth cannot be obtained without

Table 1. Study variables description.

Acronyms	Variable	Definition & measures	Source	Positioning
GGR	Green growth	Environmentally adjusted multifactor productivity growth measured in percentage points	OECD	Dependent variable
ECOM	Economic complexity	Economic complexity index assigns a ranking based on the productive capabilities	OEC	Explanatory variables
TDV	Trade diversification	International trade diversification index	UNCTAD	Explanatory variables
RENE	Renewable energy consumption	Percentage of total final energy consumption	WDI	Explanatory variables
ERT	Environment-related taxes	Environment-related taxes in US Dollars (The base year 2010)	OECD	Explanatory variables

Note: UNCTAD: United Nations Conference on Trade and Development, OECD: Organization for Economic Cooperation and Development, WDI: World development indicators, and OEC: The Observatory of Economic Complexity.
Source: Author's estimations.

incorporating the environmental issue, the implementation of ERT protects the environment. It encourages a green economy by controlling the excessive consumption of carbon-intensive energy resources and producing dirty goods. (Doğan et al., 2022) investigate the moderating impact of ERT on RENE and natural resources rent. They explore that the increase in ERT promotes green production and innovation to achieve sustainable environmental and economic goals from 1994 to 2014 in G7 countries (Sun & Razzaq, 2022; Zhuang et al. 2021).

3. Methodology

3.1. Data Summary

The prime objective of the study is to investigate the effect of economic complexity (ECOM), trade diversification (TDV), renewable energy (RENE), and environment-related taxes (ERT) on green growth (GGR) of BRICTS countries. BRICTS countries are the economic bloc of emerging countries, including Brazil, Russia, India, China, Turkey, and South Africa. The study span covers the period from 1995 to 2019 as per data availability. The dependent variable green growth refers to the green total factor productivity, the multifactor economic growth, after adjusting the environmental issues. While economic complexity refers to the economic complexity index, it is a productive capability measuring tool for large economies. Another indicator used to describe trade diversification is the international trade diversification index constructed by taking the weighted average of merchandise diversified export and import. The details of the data, such as its source and definition, has explained in Table 1.

3.2. Empirical model and theoretical framework

Based on the detailed description of the variables given in table 1, the standard approach (Copeland & Taylor, 2004) regarding trade growth and environment and the theoretical linkage discussed by (Mealy & Teytelboym, 2022) for economic complexity (Saleem et al., 2022) for trade diversification and (Hao et al., 2021) for environment-related taxes with green growth (green total factor productivity). The basic functional form of the model has been constructed as under:

$$GGR = f\ (ECOM, TDV, RENE, ERT) \tag{i}$$

Where GGR is a dependent variable refer as green growth, while the independent variables are economic complexity (ECOM), trade diversity (TDV), renewable energy (RENE), and environment-related taxes (ERT).

Equation (i) panel version of the regression model is stated below as equation (ii) in the model construction.

$$\begin{aligned} GGR_{it} = {} & \alpha_{it} + \alpha_{ECOMit}ECOM_{it} + \alpha_{TDVit}TDV_{it} + \alpha_{RENEit}RENE_{it} \\ & + \alpha_{ERTit}ERT_{it} \ + \vartheta_i \ + \mu_{it} \end{aligned} \tag{ii}$$

Where i = 1, 2, 3. … .,6t = 1995, 1996, … … , 2017, 2018

The letter 'i' illustrates the cross-section of the members of BRICTS an acronym for Brazil, Russia, India, China, Turkey, and South Africa). While 't' is the study period. Variables coefficients are presented as 'α', also known as the country-wise fixed effect. ' ϑ_i' donated as the unobserved factors influence on green growth. ' μ_{it}' presents as the error term of the regression model.

Emerging economies like BRICTS face multiple economic and environmental challenges to sustainable development. Due to the frequent economic transformations, the structural growth toward sustainability is no longer effective for these countries (Rubbo et al., 2021). Therefore, they need to adopt the alternative economic growth path, such as green growth, which is geared toward efficiently consuming economic resources, mitigating the environmental impact, and meeting sustainable development goals (SDGs-13). Green growth has become the strategic priority of emerging economies, focusing on raising the global trade in the environmental goods related to renewable energy, water waste management, and recycling systems (Mealy & Teytelboym, 2022). Economic complexity index is a common tool for economic growth or the country's productive capacity. This index determines the skills, knowledge, diversity, and ubiquity of the products. It states that economically grown and developed countries have a high ranking of ECI due to complex and diversified exports products (Caglar et al., 2022). Economic complexity accelerates sustainable economic efficiency by improving the production process, increasing economies of scale, reducing production costs by applying the specialized division of labour, and providing knowledge and technology (F. Wang et al., 2021). Therefore, the expected outcome of the nexus between economic complexity and green growth is positive $\alpha_{ECOM} = \frac{GGR}{ECOM} > 0$.

The bloc of BRICTS countries is specifically a merchandise export-based bloc of trade partners. Among them, China has the highest merchandise trade. This bloc has significantly extended the export basket in terms of diversified products in the last two decades to mitigate the impact of trade fluctuations and sudden trade shocks (Carrasco & Tovar-García, 2021). Besides this, trade diversification helps explore new markets and opportunities to strengthen economic growth (Can et al., 2021). The trade basket with eco-friendly products enhances sustainable economic and environmental growth (G. Hu et al., 2020), whereas the trade diversification portfolio with energy-intensive products may lead to environmental degradation and not support green growth. Therefore, based on the composition of the trade products, the expected outcome of the nexus between trade diversification and green growth can be positive $\alpha_{TDV} = \frac{GGR}{TDV} > 0$ and negative $\alpha_{TDV} = \frac{GGR}{TDV} < 0$.

Global policymakers have a pivotal objective to obtain green growth. The steady economic growth required high energy consumption, and this perpetual demand for energy leads to the high consumption of fossil fuels and causes serious damage to the environment. Renewable energy consumption is the best alternative to control these damages. Renewable energy sources condensed the dependency on imported fossil fuels, thus mitigating the risk of price volatility of the imported non-nonrenewable energy resources and stabilizing the economy (Hao et al., 2021). Moreover, long-run economic and environmental sustainability is also significantly reliant on cost-effective renewable energy resources, conserving energy, and reducing carbon emissions (Doğan et al., 2022). Thus, the expected association between renewable energy and green growth is positive $\alpha_{RENE} = \frac{GGR}{RENE} > 0$. Similarly, to control the environmental pollution along with the sustainable economic growth government impose taxes on the consumption of fossil fuels due to their high carbon intensity. These taxes are called environment related taxes. Also, to take the maximum benefits and to promote the consumption of renewable energy these environment related taxes used as the subsidies to enhance green growth (Hao et al., 2021). Therefore, the expected value of the coefficient to describe the nexus between environmental taxes and green growth is positive $\alpha_{ERT} = \frac{GGR}{ERT} > 0$.

3.3. Econometric strategies

It is crucial to select the right methodology for panel data analysis to obtain reliable and consistent outcomes and to provide better policy recommendations. Panel data analysis has some econometric challenges. It is extensively revolving around the issues of CR-S-DP ('cross-section dependency'), non-stationarity ('Unit root'), S-CORR ('serial correlation'), ST-BRK ('Structural break'), and S-HTR ('Slope heterogeneity'). CR-S-DP depends on cross-contrary units in high correlation (Tao et al., 2021). This interconnection of countries is attributed to the spillover effects of unobserved common factors (also known as economic or financial shocks or events due to their downturns, commodity prices, or stock indices volatility). For instance, the intensity of the global financial crisis in 2008 varies for each country, and its cross-country impact cannot be ignored. Thus, it has been assumed that the first generation's estimation techniques are unreliable because they do not address the issue of cross-country dependency. This study examines the CR-S-DP existence in the panel data by applying the (Pesaran, 2015) test. The null hypothesis of this test supports the inexistence of CR-S-DP. Subsequently, the next step to selecting the panel unit root test is important to get non-fictitious results and highly based on the CR-S-DP test outcome.

The affirmation of the CR-S-DP convergence motivates the study to select the appropriate panel unit root test. Although the first generation unit root tests of Im et al. (2003b), and Lluís Carrion-i-Silvestre et al. (2005) highlight the S-HTR and ST-

BRK failed to address the issue of CR-S-DP. In contrast, the second generation tests of Pesaran (2006) consider CR-S-DP but cannot determine the ST-BRK. Therefore, the Bai & Carrion-I-Silvestre (2009) and Pesaran (2007) tests of unit root from third-generation were found to be a more appropriate panel unit root test that accommodates both CR-S-DP issues and ST-BRK of panel data. The null hypothesis of these tests assumes that the data is not stationary. Afterward, to identify another flaw of slope homogeneity in the panel data, the study applied the test of Pesaran and Yamagata (2008) to examine the S-HTR with the null hypothesis of 'homogenous slope parameters'. Upon confirmation of the unique integration order of the panel data series, the study employed the (Westerlund & Edgerton, 2008) and (Banerjee & Carrion-I-Silvestre, 2017) tests of cointegration. The reason to select these two tests is that the first one tackle all the discussed econometric issue related to panel data, whereas the second one more precisely explains the strength of cross-sectional dependency.

In the presence of CR-S-DP and S-HTR, the use of ordinary least square (OLS) does not remain pertinent to estimating the long-run coefficient. Hence, the study assumes that the 'cross-sectionally augmented autoregressive distributed lags' (CS-ARDL) is appropriate for estimating the long-run associations among variables (Ali et al., 2021; Çoban & Topcu, 2013). CS-ARDL is the advanced panel data estimates which provide reliable estimates for long-run and short-run estimates by handling the CR-S-DP and S-HTR to suggest a common policy framework for green growth (Hao et al., 2021). The CS-ARDL model has been constructed as under:

$$GGR_{it} = \sum_{i=0}^{pu} \theta_{it} GGR_{it-1} + \sum_{i=0}^{pv} \omega_{it} V_{it-1} + \mu_{it} \tag{iii}$$

Where GGR is a dependent variable refer as green growth, while the independent variables are denoted with V, such as economic complexity (ECOM), trade diversity (TDV), renewable energy (RENE), and environment-related taxes (ERT). Equation (iii) does not address the CR-S-DP; therefore, there is a high probability that the outcomes become erroneous. Chudik & Pesaran (2015) suggested that taking the cross-section average of variables' impact on CR-S-DP has neutralized. Thus, equation (iii) is extended into equation (iv), where the cross-section average of each independent variable has been applied

$$GGR_{it} = \sum_{i=0}^{pu} \theta_{it} GGR_{it-1} + \sum_{i=0}^{pv} \omega_{it} V_{it-1} + \sum_{i=0}^{pw} \varphi_i \overline{W}_{t-1} \ \mu_{it} \tag{iv}$$

Where

$$\overline{W}_{t-1} = (\overline{GGR}_{it-1}, \overline{V}_{it-1})$$

The average value of the dependent variable $\overline{GGR}_{it-1}$ and all independent variables $\overline{V}_{it-1}$ are presents as $\overline{W}_{t-1}$. Besides this, equation (iv) pu, pv, and pw illustrate the variable lags value. In the CS-ARDL estimation approach, the long-run estimated values are measured through the value of short-run estimations. The long-run parameter estimations and the mean group estimator are presented as under:

$$\hat{\beta}_{CDARDL,i} = \frac{\sum_{I=0}^{pv} \hat{\omega}_{Ii}}{1 = \Sigma_{I=0}} \quad \theta_{I,t} \tag{v}$$

The estimator for the mean group (MG) is as under:

$$\hat{\bar{\beta}}_{MG} = \frac{1}{N} \sum_{i=1}^{N} \hat{\beta}_i \tag{vi}$$

Whereas the coefficient of the short-run relationship is as follows:

$$\begin{aligned} \Delta GGR_{it} = \delta_i[GGR_{it-1} - \alpha_i V_{it-1}] - \sum_{i=i}^{pu-1} \theta_{it}\Delta_I GGR_{it-1} \\ + \sum_{i=0}^{pv} \omega_{it}\Delta_I V_{it-1} + \sum_{i=0}^{pw} \varphi_i \overline{W}_{t-1} \ \mu_{it} \end{aligned} \tag{vii}$$

Where

$$\Delta_I = t - (t-1)$$

$$\hat{\lambda}_i = \ - \ (1 - \sum_{i=0}^{pu} \hat{\theta}_{it}) \tag{viii}$$

$$\hat{\beta}_i = \frac{\sum_{i=0}^{pv} \hat{\omega}_{it}}{\hat{\lambda}_i} \tag{ix}$$

$$\hat{\bar{\beta}}_{MG} = \frac{1}{N} \sum_{i=1}^{N} \hat{\beta}_i \tag{x}$$

The value of the error correction model (ECM) should be significant, and negative varies from negative 1 to zero, which confirms the stability of the model and its adjustment toward the long-run adjustment. The econometric strategy of this study incorporates two tests of the 'Augmented Mean Group' (AGM) estimator and 'Common Correlated Effect Mean Group' (CCEMG) suggested by (Eberhardt & Teal, 2010) and (Pesaran, 2006), respectively, to check the robustness of CS-ARDL.

4. Analysis and discussion

As discussed earlier, to avoid erroneous results of the study, it is essential to consider the issue of CR-S-DP. From Table 2, the outcomes of the Pesaran (2015) cross-

Table 2. Cross-sectional dependence test results.

Variable	Test statistics (p-values)
GGR	16.153*** (0.000)
ECOM	20.069*** (0.000)
TDV	15.136*** (0.000)
RENE	9.074*** (0.000)
ERT	13.160*** (0.000)

Note: *** illustrate 1% significance level.
Source: Author's estimations.

Table 3. Slope heterogeneity test outcomes.

Statistics	Test value (P-value)
Delta tilde	79.162*** (0.000)
Delta tilde adjusted	65.210*** (0.000)

Note: *** illustrates a 1% significance level.
Source: Author's estimations.

sectional dependency test show the significant value of all the variables such as green growth, economic complexity, trade diversification, renewable energy, and environmental-related taxes. Thus, the null hypothesis of 'no cross-sectional dependency' has been rejected by all and confirms the CR-S-DP in all panel data variables

Likewise, the CR-S-DP, the slope heterogeneity(S-HTR), is also a crucial issue that needs to be addressed to obtain reliable outcomes for the study. To serve the object, the (Pesaran & Yamagata, 2008) test results illustrated in Table 3 show that the null hypothesis has been rejected at a 1% level of significance which assumes the 'slope homogeneity' in the panel data. Hence, the high slope weight dispersion or model slope homogeneity has been affirmed.

Based on the strong evidence of CR-S-DP and S-HTR, it has been discovered that the BRICTS countries are interrelated and reliant on each other. Therefore, the study used the unit root tests of Pesaran (2007) and Bai & Carrion-I-Silvestre (2009). The outcome of these tests in Table 4 revealed that the null hypothesis of 'unit root present' has been significantly rejected by Pesaran (2007) at the level. Whereas, under Bai & Carrion-I-Silvestre (2009) panel unit root test, the null hypothesis of 'unit root present' has significantly rejected at first difference.

To determine the long-run association among dependent and independent variables such as green growth, economic complexity, trade diversification, renewable energy, and environmental-related taxes, the two cointegration tests of Westerlund and Edgerton (2008) and Banerjee & Carrion-I-Silvestre (2017) are applied. Tables 5 and 6 illustrate the outcomes of these two tests. According to the results of Westerlund and Edgerton (2008), the null hypothesis of 'no cointegration' has been rejected at No break, Mean shift, and regime shift at a 1% significance level and endorses the long-run association between study variables.

Correspondingly, the long-run correlation between green growth, economic complexity, trade diversification, renewable energy, and environmental-related taxes has also been endorsed by Banerjee & Carrion-I-Silvestre (2017) for the individual members and a full sample of BRICTS countries.

The outcomes of the above two tests confirm the existence of long-run association among variables and motivate the study to move toward the main analysis strategy of

Table 4. Pesaran (2007) Unit root test results.

	Level I(0)		First difference I(1)	
Variables	CIPS	M-CIPS	CIPS	M-CIPS
GGR	−4.120***	−6.008**	–	–
ECOM	−3.164***	−3.194**	–	–
TDV	−5.031***	−5.072**	–	–
RENE	−3.182***	−4.129**	–	–
ERT	−4.156***	−3.166**	–	–

Bai & Carrion-I-Silvestre (2009)

	GGR	ECOM	TDV	RENE	ERT
Z	0.168	0.245	0.173	0.3	0.269
Pm	0.315	0.183	0.274	0.159	0.2
P	17.145	21.063	18.139	23.02	16.174
Z	−3.185***	−6.001***	−3.169***	−5.073***	−4.126***
Pm	4.132***	5.041***	3.173***	4.150***	3.169***
P	81.035***	63.164***	75.128***	59.190***	66.155***

Note: *** <1%, ** <5% level of significance respectively. The critical values (CV) for *Z* and *Pm* statistics under Bai & Carrion-I-Silvestre (2009) test, are 2.326, 1.645 and 1.282 and for *P* are 56.06, 48.60 and 44.90, separately.
Source: Author's estimations.

Table 5. Panel cointegration test results of Westerlund and Edgerton (2008).

Test	$Z_{\varphi}(N)$	P_{value}	$Z_{\tau}(N)$	P_{value}
$NB_{(No\ break)}$	−5.004***	0	−5.098***	0
$MS_{(Mean\ shift)}$	−6.065***	0	−4.453***	0
$RS_{(Regime\ shift)}$	−5.882***	0	−5.310***	0

Note: *** < 1% significance level.
Source: Author's estimations.

Table 6. Results of Banerjee & Carrion-I-Silvestre (2017) cointegration analysis.

Countries	No deterministic specification	With trend
Dependent variable: green growth		
Full sample	−4.320***	−3.975***
Brazil	−5.738***	−6.472***
Russia	−3.418**	−3.253**
India	−4.956***	−4.176***
China	−6.103***	−5.115***
Turkey	−5.944***	−4.890***

Note: Critical Value (CV) at 5%** and 10%*.
Source: Author's estimations.

CS-ARDL to obtain long-run dynamics and short-run influence of independent variables such as economic complexity, trade diversification, renewable energy, and environmental taxes on the dependent variable of green growth. Table 7 presents the long-run coefficient of the variables, which illustrates that the independent variables such as economic complexity, trade diversification, renewable energy, and environmental taxes have a positive and significant influence on green growth in the long run for BRICTS countries. The positive association of economic complexity with green growth has explained that economic complexity is the ability of the specific economy to efficiently allocate its resources, bring knowledge and technology to enhance production capabilities (Zhuang et al., 2021), and diversify the products. ECI has increased the green growth efficiency of the country. These findings are consistent with the study of (F. Wang et al., 2021), who state that the increase in economic complexity plays a major role in enhancing green growth.

Table 7. Estimates of CS-ARDL.

	Long-run estimates			Short-run estimates		
Variables	Coefficients	t-statistics	p-values	Coefficients	t-statistics	p-values
ECOM	−0.264***	−3.064	0.000	−0.064*	−1.723	0.083
TDV	0.175**	2.053	0.045	0.028***	4.702	0.000
RENE	0.341***	5.987	0.000	0.121***	4.148	0.000
ERT	0.286***	4.100	0.000	0.072***	3.913	0.000
ECT(-1)	–	–	–	−0.295***	−3.375	0.000

Note: ***, ** & * explain the level of significance at 1%, 5% and 10% respectively.

Table 8. Robustness test.

	AMG			CCEMG		
Variables	Coefficients	t-statistics	p-values	Coefficients	t-statistics	p-values
ECOM	−0.196***	−3.901	0.000	−0.253***	−3.945	0.000
TDV	0.258***	4.063	0.000	0.224***	5.071	0.000
RENE	0.163***	3.185	0.000	0.199***	4.127	0.000
ERT	0.220***	6.742	0.000	0.268***	3.639	0.000
Wald test	–	14.062	0.000	–	8.331	0.000

Note: ***, ** & * explain the level of significance at 1%, 5% and 10% respectively.

Likewise, the CS-ARDL long-run estimates for trade diversification show its positive impact on green growth at a 5% significance level because trade diversification changes the composition of the traded products and provides vast opportunities for trading. It mitigates the trade risk and impact of price shocks by expanding the trade portfolio. Thus, stabilizing the revenue and promoting the trade of eco-friendly goods and services to enhance green growth. The outcome illustrates that the nexus of trade diversification and green growth is in line with the study results (Can et al., 2021; Carrasco & Tovar-García, 2021). Similarly, the long-run positive association between renewable energy and green growth exhibit that in the long run, renewable energy consumption in BRICTS countries enhances green growth by being cost-effective, energy-conservative, emission-reducer energy sources. The finding of the CS-ARDL estimate is similar to the discoveries of (Alper & Oguz, 2016; İnal et al., 2022; Tawiah et al., 2021). In addition, the environment-related tax also shows that the increase in tax level aid green growth and discourages fossil fuel consumption from obtaining environmental and economic sustainability in the long run for BRICTS countries. The findings are consistent with the study outcomes of (Hao et al., 2021; Kwilinski et al., 2019), who suggested that environment-related taxes control carbon-intensive energy resource consumption and promote renewable energy resources for production; therefore, economic stability has retained, and green growth encouraged.

The short-run estimates of CS-ARDL are also illustrated in Table 7, demonstrating that all the independent variables, such as economic complexity, trade diversification, RENE, and ERT, positively correlate with the dependent variable of GGR for BRICTS countries. These results endorse the long-run results regarding the nature of variables association. However, the economic complexity significance level has varied. The positive association between economic complexity and green growth is significant at a 10% level of significance in the short-run. Thus, it has been confirmed that all the study's independent variables support the green growth in the short-run for BRICTS countries. In addition, the coefficient value of the 'error correction model' ECM is significantly negative, which affirms the stability and reliability of the economic model to return toward equilibrium.

In addition, for the robustness check, the study applied the 'Augmented Mean Group' (AGM) and 'Common Correlated Effect Mean Group' (CCEMG) introduced by (Eberhardt & Teal, 2010) and (Pesaran, 2006), respectively. From Table 8, the estimates of AGM and CCEMG have corroborated the association among variables derived from the CS-ARDL test. For instance, the economic complexity, trade diversification, renewable energy, and environment-related taxes enhance green growth in BRICTS countries.

5. Conclusion and policy recommendations

Sustainable economic growth is the primary concern of economies and international organizations for the well-being of humanity. Green growth is the most appropriate path with a comprehensive and integrated economic approach that ensures the potential economic deliverables of the natural capital on a sustainable basis. Existing studies have explored various factors that drive green growth; however, as per our knowledge, not a single study has been carried out to explore economic complexity, trade diversification, and environment-related taxes as the core driver of achieving green growth targets emerging economies like BRICTS countries. This study took the initiative to determine the impact of economic complexity, trade diversification, and environment-related taxes on the green growth of BRICTS countries from 1995 to 2018. Emerging economies like BRICTS face multiple economic and environmental challenges to sustainable development. Since frequent economic transformations occur, the structural growth toward sustainability is no longer effective in these countries. Therefore, the suggested alternative economic growth path is green growth, which fosters the efficient consumption of economic capital, mitigating the environmental impact, and meeting sustainable development goals (SDGs-13).

The study has employed various tests to address the panel data econometric issues of 'cross-section dependency, slope heterogeneity, structural breaks, serial correlation'. The stationarity of the panel data series has obtained at first difference under the test of Bai & Carrion-I-Silvestre (2009), while Pesaran (2007) suggests the integration at the level. The mixed integration order and the affirmation of cointegration among variables have motivated the study to implement the CS-ARDL test. The CS-ARDL estimations have estimated the long-run and short-run estimates to investigate the real association between economic complexity, trade diversification, environment-related taxes, and green growth. The finding of the CS-ARDL suggests that in the long-run and short-run, all the study variable have a constructive impact on green growth. The study has measured the green growth of these countries in terms of the economic complexity index, which determines the skills, knowledge, diversity, and ubiquity of the product. The positive association of ECI shows the increase in ECI boost the economic sustainability with more complex and diversified export products in these countries. Similarly, the extended portfolio of trade diversification accelerates the green growth and neutralize the carbon impact of high economic growth.

Additionally, the renewable energy and environment related taxes are work as useful strategy to promote green growth in BRICTS countries, these results were affirmed by the 'Augmented Mean Group' (AGM) and 'Common Correlated Effect Mean Group' (CCEMG) test for robustness check.

After determining the positive association between economic complexity, trade diversification, renewable energy, and environment-related taxes, this paper has proposed the following policy recommendation to promote green growth in BRICTS countries. Economic complexity indicates the diversification of industrialized exports, production capabilities, and the country's competitiveness. Therefore, this economic bloc needs to significantly emphasize the economic complexity and the diversification of the industries by introducing advanced technology and knowledge-based industrial practices. Moreover, this transformation toward the technology and knowledge-based productive structure contributes to attaining green growth and carbon neutrality targets and provides the comparative advantage to support regional competitiveness. Countries like South Africa that witnessed a sharp decline in the ECI are narrowly attentive to their productive capabilities; therefore, these countries need to focus more on resource management to develop their productive capacities to align with future green growth. The BRICTS countries' bloc trade is based on energy-intensive products (cement, iron, oil refineries, and heavy engineering). It has been suggested that to achieve sustainable economic and environmental goals; they should invest in renewable energy resources to meet the energy demand. The government should encourage investment in renewable energy projects by offering grants, subsidies, loans, and tax holidays. However, they should implement energy mix strategies until the transformation from non-renewable to renewable energy. Moreover, by widening the trade portfolio in export and import diversification, they should extend the number of distinct products and categorize them based on their demand and environmental impact to foster green growth. Besides this, they should impose heavy taxes or trade duties on importing and producing high-energy-intensive products.

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References

Acosta, L. A., Maharjan, P., Peyriere, H. M., & Mamiit, R. J. (2020). Natural capital protection indicators: Measuring performance in achieving the Sustainable Development Goals for

green growth transition. *Environmental and Sustainability Indicators*, *8*, 100069. https://doi.org/10.1016/j.indic.2020.100069
Adebayo, T. S., Rjoub, H., Akadiri, S. S., Oladipupo, S. D., Sharif, A., & Adeshola, I. (2022). The role of economic complexity in the environmental Kuznets curve of MINT economies: evidence from method of moments quantile regression. *Environmental Science and Pollution Research International*, *29*(16), 24248–24260. https://doi.org/10.1007/s11356-021-17524-0
Ahmad, M. I., Ur Rehman, R., Naseem, M. A., & Ali, R. (2021). Do environmental taxes impede economic growth? A comparison between China and India. *International Journal of Financial Engineering*, *8*(04), 2050023. https://doi.org/10.1142/S2424786320500231
Ali, S., Dogan, E., Chen, F., & Khan, Z. (2021). International trade and environmental performance in top ten-emitters countries: The role of eco-innovation and renewable energy consumption. *Sustainable Development*, *29*(2), 378–387. https://doi.org/10.1002/sd.2153
Alper, A., & Oguz, O. (2016). The role of renewable energy consumption in economic growth: Evidence from asymmetric causality. *Renewable and Sustainable Energy Reviews*, *60*, 953–959. https://doi.org/10.1016/j.rser.2016.01.123
Aydoğan, B., & Vardar, G. (2020). Evaluating the role of renewable energy, economic growth and agriculture on CO2 emission in E7 countries. *International Journal of Sustainable Energy*, *39*(4), 335–348. https://doi.org/10.1080/14786451.2019.1686380
Bai, J., & Carrion-I-Silvestre, J. L. (2009). Structural changes, common stochastic trends, and unit roots in panel data. *Review of Economic Studies*, *76*(2), 471–501. https://doi.org/10.1111/j.1467-937X.2008.00530.x
Banerjee, A., & Carrion-I-Silvestre, J. L. (2017). Testing for panel cointegration using common correlated effects estimators. *Journal of Time Series Analysis*, *38*(4), 610–636. https://doi.org/10.1111/jtsa.12234
Caglar, A. E., Guloglu, B., & Gedikli, A. (2022). Moving towards sustainable environmental development for BRICS: Investigating the asymmetric effect of natural resources on CO_2. *Sustainable Development*, *30*(5), 1313–1325. https://doi.org/10.1002/sd.2318
Caglar, A. E., Zafar, M. W., Bekun, F. V., & Mert, M. (2022). Determinants of CO_2 emissions in the BRICS economies: The role of partnerships investment in energy and economic complexity. *Sustainable Energy Technologies and Assessments*, *51*, 101907. https://doi.org/10.1016/j.seta.2021.101907
Can, M., Ahmad, M., & Khan, Z. (2021). The impact of export composition on environment and energy demand: Evidence from newly industrialized countries. *Environmental Science and Pollution Research*, *28*(25), 33599–33612. https://doi.org/10.1007/s11356-021-13084-5
Carrasco, C. A., & Tovar-García, E. D. (2021). Trade and growth in developing countries: The role of export composition, import composition and export diversification. *Economic Change and Restructuring*, *54*(4), 919–941. https://doi.org/10.1007/s10644-020-09291-8
Charles, A., Mesagan, E., & Saibu, M. (2018). Resource endowment and export diversification: Implications for growth in Nigeria. *Studies in Business and Economics*, *13*(1), 29–40. https://doi.org/10.2478/sbe-2018-0003
Chen, J., Hu, X., Razi, U., & Rexhepi, G. (2021). The sustainable potential of efficient air-transportation industry and green innovation in realising environmental sustainability in G7 countries. *Economic Research-Ekonomska Istrazivanja*, *35*(1), 3814–3835. https://doi.org/10.1080/1331677X.2021.2004190
Çoban, S., & Topcu, M. (2013). The nexus between financial development and energy consumption in the EU: A dynamic panel data analysis. *Energy Economics*, *39*, 81–88. https://doi.org/10.1016/j.eneco.2013.04.001
Copeland, B. R., & Taylor, M. S. (2004). Trade, growth, and the environment. *Journal of Economic Literature*, *42*(1), 7–71. https://doi.org/10.1257/002205104773558047
Doğan, B., Chu, L. K., Ghosh, S., Diep Truong, H. H., & Balsalobre-Lorente, D. (2022). How environmental taxes and carbon emissions are related in the G7 economies? *Renewable Energy*. *187*, 645–656. https://doi.org/10.1016/j.renene.2022.01.077

Dordmond, G., de Oliveira, H. C., Silva, I. R., & Swart, J. (2021). The complexity of green job creation: An analysis of green job development in Brazil. *Environment, Development and Sustainability*, *23*(1), 723–746. https://doi.org/10.1007/s10668-020-00605-4

Eberhardt, M., & Teal, F. (2010). Productivity analysis in global manufacturing production. *Eco-nomics Series*, 2010 (515). https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.983.4340&rep=rep1&type=pdf

Fan, X., Li, X., & Yin, J. (2019). Impact of environmental tax on green development: A nonlinear dynamical system analysis. *Plos One*, *14*(9), e0221264. https://doi.org/10.1371/journal.pone.0221264

Fraccascia, L., Giannoccaro, I., & Albino, V. (2018). Green product development: What does the country product space imply? *Journal of Cleaner Production*, *170*, 1076–1088. https://doi.org/10.1016/j.jclepro.2017.09.190

Gao, J., & Zhou, T. (2018). Quantifying China's regional economic complexity. *Physica A: Statistical Mechanics and Its Applications*, *492*, 1591–1603. https://doi.org/10.1016/j.physa.2017.11.084

GGGI (2021). *Green growth index – Measuring performance in achieving SDG targets*. Greengrowthindex.Gggi.Org. https://greengrowthindex.gggi.org/

Hao, L. N., Umar, M., Khan, Z., & Ali, W. (2021). Green growth and low carbon emission in G7 countries: How critical the network of environmental taxes, renewable energy and human capital is? *The Science of the Total Environment*, *752*, 141853. https://doi.org/10.1016/j.scitotenv.2020.141853

Hausmann, R., Hidalgo, C. A., Bustos, S., Coscia, M., Simoes, A., & Yildirim, M. A. (2014). The atlas of economic complexity: Mapping paths to prosperity. *The Atlas of Economic Complexity*, https://doi.org/10.7551/MITPRESS/9647.001.0001

Hidalgo, C. A., & Hausmann, R. (2009). The building blocks of economic complexity. *Proceedings of the National Academy of Sciences of the United States of America*, *106*(26), 10570–10575. https://doi.org/10.1073/pnas.0900943106

Hu, G., Can, M., Paramati, S. R., Doğan, B., & Fang, J. (2020). The effect of import product diversification on carbon emissions: New evidence for sustainable economic policies. *Economic Analysis and Policy*, *65*, 198–210. https://doi.org/10.1016/j.eap.2020.01.004

Hu, J., Xu, J., Tong, L., & Razi, U. (2022). The dynamic role of film and drama industry, green innovation towards the sustainable environment in China: Fresh insight from NARDL approach. *Economic Research-Ekonomska Istrazivanja*, *35*(1), 5292–5309. https://doi.org/10.1080/1331677X.2022.2026239

Im, K. S., Pesaran, M. H., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics*, *115*(1), 53–74. https://doi.org/10.1016/S0304-4076(03)00092-7

İnal, V., Addi, H. M., Çakmak, E. E., Torusdağ, M., & Çalışkan, M. (2022). The nexus between renewable energy, CO_2 emissions, and economic growth: Empirical evidence from African oil-producing countries. *Energy Reports*, *8*, 1634–1643. https://doi.org/10.1016/j.egyr.2021.12.051

Jiang, S., Mentel, G., Shahzadi, I., Ben Jebli, M., & Iqbal, N. (2022). Renewable energy, trade diversification and environmental footprints: Evidence for Asia-Pacific Economic Cooperation (APEC). *Renewable Energy*. *187*, 874–886. https://doi.org/10.1016/j.renene.2021.12.134

Klymenko, M. (2019). Environmental taxation as a policy instrument for green growth. *Zeszyty Naukowe SGGW w Warszawie - Problemy Rolnictwa Światowego*, *19*(3), 35–45. https://doi.org/10.22630/PRS.2019.19.3.44

Kwilinski, A., Ruzhytskyi, I., Patlachuk, V., Patlachuk, O., & Kaminska, B. (2019). Environmental taxes as a condition of business responsibility in the conditions of sustainable development. *Journal of Legal, Ethical and Regulatory Issues*, *22*, 1–6. https://www.proquest.com/docview/2330971709?pq-origsite = gscholar&fromopenview = true

Lluís Carrion-i-Silvestre, J., Del Barrio-Castro, T., & López-Bazo, E. (2005). Breaking the panels: An application to the GDP per capita. *The Econometrics Journal*, *8*(2), 159–175. https://doi.org/10.1111/j.1368-423X.2005.00158.x

Mania, E., & Rieber, A. (2019). Product export diversification and sustainable economic growth in developing countries. *Structural Change and Economic Dynamics*, *51*, 138–151. https://doi.org/10.1016/j.strueco.2019.08.006

Mealy, P., & Teytelboym, A. (2022). Economic complexity and the green economy. *Research Policy*, *51*(8), 103948. https://doi.org/10.1016/j.respol.2020.103948

Munir, K., & Javed, Z. (2018). Export composition and economic growth: Evidence from South Asian countries. *South Asian Journal of Business Studies*, *7*(2), 225–240. https://doi.org/10.1108/SAJBS-10-2017-0117

OECD. (2018). What is green growth and how can it help deliver sustainable development? – OECD. *OECD.Org*. https://www.oecd.org/greengrowth/whatisgreengrowthandhowcanithelp-deliversustainabledevelopment.htm

Pesaran, M. H. (2006). Estimation and inference in large heterogeneous panels with a multifactor error structure. *Econometrica*, *74*(4), 967–1012. https://doi.org/10.1111/j.1468-0262.2006.00692.x

Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics*, *22*(2), 265–312. https://doi.org/10.1002/jae.951

Pesaran, M. H. (2015). Testing weak cross-sectional dependence in large panels. *Econometric Reviews*, *34*(6–10), 1089–1117. https://doi.org/10.1080/07474938.2014.956623

Pesaran, M. H., & Yamagata, T. (2008). Testing slope homogeneity in large panels. *Journal of Econometrics*, *142*(1), 50–93. https://doi.org/10.1016/j.econlet.2013.09.012

Qi, S., & Li, Y. (2017). Threshold effects of renewable energy consumption on economic growth under energy transformation. *Chinese Journal of Population Resources and Environment*, *15*(4), 312–321. https://doi.org/10.1080/10042857.2017.1416049

Rubbo, P., Picinin, C. T., & Pilatti, L. A. (2021). Innovation and economic complexity in BRICS. *International Journal of Knowledge Management Studies*, *12*(1), 66–79. https://doi.org/10.1504/IJKMS.2021.112222

Saleem, R., Nasreen, S., & Azam, S. (2022). Role of financial inclusion and export diversification in determining green growth: Evidence from SAARC economies. *Environmental Science and Pollution Research*, *29*(40), 60327–60340. https://doi.org/10.1007/s11356-022-20096-2

Sepehrdoust, H., Tartar, M., & Gholizadeh, A. (2022). Economic complexity, scientific productivity and income inequality in developing economies. *Economics of Transition and Institutional Change*, *30*(4), 737–752. https://doi.org/10.1111/ecot.12309

Sohag, K., Husain, S., Hammoudeh, S., & Omar, N. (2021). Innovation, militarization, and renewable energy and green growth in OECD countries. *Environmental Science and Pollution Research International*, *28*(27), 36004–36017. https://doi.org/10.1007/s11356-021-13326-6

Song, Y., Zhao, P., Chang, H. L., Razi, U., & Dinca, M. S. (2022). Does the COVID-19 pandemic affect the tourism industry in China? Evidence from extreme quantiles approach. *Economic Research-Ekonomska Istraživanja*, *35*(1), 2333–2350. https://doi.org/10.1080/1331677X.2021.1941180

Spinesi, L. (2022). The environmental tax: Effects on inequality and growth. *Environmental and Resource Economics*, *82*(3), 529–572. https://doi.org/10.1007/s10640-022-00662-5

Sun, Y., & Razzaq, A. (2022). Composite fiscal decentralisation and green innovation: Imperative strategy for institutional reforms and sustainable development in OECD countries. *Sustainable Development.*, *30*(5), 944–957. https://doi.org/10.1002/sd.2292

Sun, Y., Bao, Q., Siao-Yun, W., Ul Islam, M., & Razzaq, A. (2022). Renewable energy transition and environmental sustainability through economic complexity in BRICS countries: Fresh insights from novel Method of Moments Quantile regression. *Renewable Energy*. *184*, 1165–1176. https://doi.org/10.1016/j.renene.2021.12.003

Tao, R., Umar, M., Naseer, A., & Razi, U. (2021). The dynamic effect of eco-innovation and environmental taxes on carbon neutrality target in emerging seven (E7) economies. *Journal of Environmental Management*, *299*, 113525. https://doi.org/10.1016/j.jenvman.2021.113525

Tawiah, V., Zakari, A., & Adedoyin, F. F. (2021). Determinants of green growth in developed and developing countries. *Environmental Science and Pollution Research International*, *28*(29), 39227–39242. https://doi.org/10.1007/s11356-021-13429-0

Trinh, P. T. T., & Thuy, H. T. T. (2021). Export diversification and economic growth: A threshold regression approach for emerging markets and developing countries. *Economic Journal of Emerging Markets*, *13*(2), 188–199. https://doi.org/10.20885/ejem.vol13.iss2.art8

Usman, M., Makhdum, M. S. A., & Kousar, R. (2021). Does financial inclusion, renewable and non-renewable energy utilization accelerate ecological footprints and economic growth? Fresh evidence from 15 highest emitting countries. *Sustainable Cities and Society*, *65*, 102590. https://doi.org/10.1016/j.scs.2020.102590

Wang, F., Wu, M., & Wang, J. (2021). Can Increasing economic complexity improve China's green development efficiency? *SSRN Electronic Journal*, Available at SSRN 3985233. https://doi.org/10.2139/ssrn.3985233

Wang, Y., Zhang, D., Ji, Q., & Shi, X. (2020). Regional renewable energy development in China: A multidimensional assessment. *Renewable and Sustainable Energy Reviews*, *124*, 109797. https://doi.org/10.1016/j.rser.2020.109797

Westerlund, J., & Edgerton, D. L. (2008). A simple test for cointegration in dependent panels with structural breaks. *Oxford Bulletin of Economics and Statistics*, *70*(5), 665–704. https://doi.org/10.1111/j.1468-0084.2008.00513.x

Zhuang, Y., Yang, S., Razzaq, A., & Khan, Z. (2021). Environmental impact of infrastructure-led Chinese outward FDI, tourism development and technology innovation: a regional country analysis. *Journal of Environmental Planning and Management*, *0*(0), 1–33. https://doi.org/10.1080/09640568.2021.1989672

Zhang, W., Hu, J., & Hao, J. (2022). Proportion of renewable energy consumption and economic growth: Theoretical and empirical analysis. *Environmental Science and Pollution Research International*, *29*(19), 28884–28895. https://doi.org/10.1007/s11356-022-18500-y

Zhang, Z., Xi, L., Bin, S., Yuhuan, Z., Song, W., Ya, L., Hao, L., Yongfeng, Z., Ashfaq, A., & Guang, S. (2019). Energy, CO_2 emissions, and value added flows embodied in the international trade of the BRICS group: A comprehensive assessment. *Renewable and Sustainable Energy Reviews*, *116*, 109432. https://doi.org/10.1016/j.rser.2019.109432