Nexus between fiscal imbalances, green fiscal spending, and green economic growth: empirical findings from E-7 economies

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Abstract
The green economy is viewed as a cost-effective means of achieving sustainability around the globe, and a recent study inferred the nexus between the fiscal imbalances and green economic growth based on E-7 economies data. This paper attempts to answer how green fiscal spending ensures green economic growth and stabilizes fiscal imbalances in E-7 economies. The study findings highlighted the mechanism and viability of green fiscal spending for fiscal imbalances and green economic growth. More specifically, results showed that green fiscal spending extends green economic growth in Brazil with 30%, in China with 44%, in India with 11.8%, in Indonesia with 34%, Russia with 29.7%, and Turkey with 22.4%, respectively. Based on the findings, the following are our recommendations: (i) local governments should rebalance their fiscal budgets and invest more on public goods to assess local sustainable development, and (ii) several development initiatives specific to the local level should be employed to maximize fiscal spending.

Keywords E-7 countries · Fiscal imbalances · Green fiscal spending · Green economic growth · OLS technique

1 Introduction
Green economic growth promotion has significant practical implications, whereas green economic growth and sustainable development are compatible. Nowadays, humankind’s materialistic needs are met with the rapid growth of the world economy, but at a high cost of resources and environment by every country. In the...
era of global pollution and warming, people are being forced to seek innovative approaches to achieving long-term sustainability, while people’s inability to prioritize local issues over external issues is an inkling of unresolved problems caused by pollution (Kordej-De Villa and Slijepcevic 2019; Khosravi et al. 2019; Yadav et al. 2021). Economic progress, conserve natural resources, and environmental stewardship are three pillars of the green market (Ozoike-Dennis et al. 2019; Hilbers et al., 2019). Despite the relevance of the green economy, it is vital to thoroughly investigate the factors influencing its development. These researches focus on one of the crucial metrics of green economic growth, fiscal expenditure (Hakuzimana and Masasi 2020; Gao et al. 2021). Existing research shows that the composition of fiscal spending changes as the economy and the environment get worse. There is still a lot of uncertainty (Umar and Akhtar 2021; Ngo et al. 2021). In reality, the economic growth of some countries has exceeded 50% over the past decade, making them the most important economic leaders in the world. For example, India and China’s annual gross domestic product (GDP) growth rates are significantly higher than the global average (Tao and Wang 2020). Studies have shown that changes in the mix of fiscal expenditure affect the economy and emissions, but there is no comprehensive economic development (Lin and Zhu 2019; Taghizadeh-Hesary and Yoshino 2015; 2020).

Depending on where you live, the impact of financial inclusion on GEE may seem diverse (Lei et al. 2021; Li 2020). Based on the perception of administration complexity in each state, data in this study are currently divided into strict and moderate environmental administration (Guan and Li 2020). The replacement for national municipalities’ institutional framework is the amount of revenue invested locally (Iqbal et al. 2021; Zhang et al. 2021). The municipal state’s desire and ways to sustain the climate will increase concerning the quantity invested. Areas with good regulatory administration are those where demand for environmentally friendly expenditure is greater than average (Mulongo and Kholopane 2018; Gonzalez and Enríquez-De-Salamanca 2018). The following steps are used to prepare this documenting to calculate the greener economic expansion indicator (GEGI) (Li et al. 2021; Chien et al. 2021; Iqbal et al. 2021). This function accounts for changes in economic growth, available resources, and environmental conditions. During the research period, variation of GEGI was discovered. A substantial and positive influence of education and research and development (R&D) investment on GEGI was found using the System-OLS estimator, confirming the presence of the compositional and technical effects. Analyzing the sub-samples demonstrates the influence of compositional and method heterogeneity in places with varying degrees of resource abundance (Taghizadeh-Hesary and Yoshino, 2019, 2020). Meanwhile, it has been seen that the arrangement impact always outweighs the method effect.

The study investigated the possible effect of fiscal expenditure on green economic growth and found that educational funding may encourage sentient processes and outputs, while R&D investment can increase technical advancement. The findings contributed to existing knowledge of the function of budgetary expenditure. Previous studies on the impact of government expenditure on the market have not been conclusive, and this is a major issue we have resolved. Content and method impacts are shown to exist in this research, which supports the idea that increasing fiscal
expenditure on public goods alleviates market distortion. This article also provides fresh evidence for the association between fiscal expenditure and green economic development. All three are intertwined, and the renewable energy industry must strike a balance between them since government rules influence them all. Government spending on public goods might be an effective way to encourage green economic development. Furthermore, the study provides specific policy recommendations, especially for China’s various cities, to ensure long-term sustainable development. According to our research, China’s cities are not homogeneous, and financial investment has diverse effects in various locations. Therefore, different city-level development strategies should therefore be developed to fully utilize the role of fiscal expenditure in the sustainable future. This study examined the value of education and R&D investment in determining the impact of fiscal spending on green economic development in E-7 economies by using econometric estimation. Accastello et al. (2019), Molla et al. (2019), and Pinto et al. (2019) attempted to discover the composition effect and the technique effect. In contrast, the geographical variability in these cities may offer us sufficient data variability to accomplish the identification technique. Study contribution also includes the development of policy implications based on the findings.

The rest of the paper is organized as follows: Sect. 2 contains the literature review, Sect. 3 explains the data and methodology, Sect. 4 shows results and discussion, and Sect. 5 concludes the study.

2 Literature review

Various governments and organizations worldwide are concerned about the notion of “green financial activity” and “promoting biodiversity” as a means of reducing environmental deterioration, custodial measures, and even promoting economic growth (Musango et al. 2014; Lin and Zhu 2019; Agyekum et al. 2021; Zhang et al. 2021). Governmental bodies have accepted the green economy as a crucial power notion from many research and organizations. Several studies have analyzed the definition and primary consequences of inclusive. Loiseau et al. (2016) used bibliometric analysis to first define and analyze the link between green economy and sustainability (Mohsin et al. 2020, 2018, 2021a). Numerous researches on the green economy growth showed that transitioning to a green economy can help reduce greenhouse gas emissions and conserve natural resources (Musango et al. 2014; Lin and Zhu 2019). Reilly (2012) determined that green development has three primary goals: economic growth, environmental preservation, and employment creation.

Chandio et al. (2020) and Sun et al. (2020a, b) assessed 285 Chinese cities for their broader development effectiveness. Green infrastructure differs amongst energy sources in Chinese cities (Chai et al. 2019; Yang et al. 2019). Many researches have been carried out to determine the components that contribute to green development. Avraam et al. (2020) examined an empirical approach to determine the green economy’s growth scenario and socioeconomic variables.

Based on city-level data from China, Li and Xu (2018) looked at the effect of having a lot of natural resources on green growth. They found a “resource curse,”
meaning places with many resources also tend to experience environmental deterioration Pan et al. (2019) used a panel vector auto-regression model to explore the variables that influence the low-carbon economy index in China’s provinces. Sun et al. (2020b) and Baloch et al. (2020) looked into how China’s green economy grew when it switched from electricity to gas and diesel.

Trotta (2020) have looked into the green financing and investment concerning various financial, ecological, and electricity factors. Mohsin et al. (2019, 2020, Mohs in et al., 2021a, b) investigated China’s stable growth and manufacturing carbon intensity, among other things. Carbon dioxide (CO₂) emissions and their long-term drivers were shown to be linked using an autoregressive distributed lags (ARDL) cointegration technique. Green investment and the use of renewable energy significantly reduce manufacturing CO₂ emissions, while trade openness increases them. Both of these features, as a result, are crucial for China’s long-term prosperity. This year’s Covid-19 presents a worldwide issue to all sectors, even if green development is linked to sustainable growth. In this respect, a study was conducted by Tiep et al. (2021) on green bonds markets to explore their function as facilitators of post-Covid-19 green financing. There were two methods employed in the study: pooled OLS and random effect GLS. According to empirical studies, despite the increased risk and variability, green bonds exhibited better returns. According to the survey, the banking sector accounts for 60% of the green bond market. In contrast, the returns on green bonds issued by the banking industry were lower (Tiep et al. 2021).

Nowadays, the financial system has a weaker ability to absorb unexpected risks than previously thought. Some banking institutions and marketplaces in Covid-19 have collapsed due to this fact. There must be strong environmental policies that take into account carbon-free and ecologically friendly techniques to accomplish ecologically sustainable objectives. Environmental sustainability can be achieved via the use of environmentally friendly policies such as environmental loans and debt securities (Alemzero et al. 2020b, 2020a; Sun et al. 2020a). Rosman et al. (2014) investigated the Covid-19 pandemic for optimum sustainable development goals (SDGs) portfolio selection. An optimal allocation model for SDGs was theoretically created in their work. It has been shown that investment portfolios have been distorted due to the current assignment of SDGs by different advising businesses. In other words, taxing air contaminants and pollutants is the only way to obtain the required portfolio allocations.

According to research by Berk et al. (2020), planning for green manufacturing and a carbon tax might be an effective way to deal with environmental challenges such as fuel regeneration, CO₂ emissions, and trash repurposing. A study by Feng and He (2020) found that incorporating the newest technologies response such as energy storage, heat pumps, heat, and power demands boosts energy efficiency into China’s 2020 energy system and also cuts yearly fuel efficiency costs. Investments in environmentally friendly initiatives significantly reduce environmental dangers and increase the use of renewable energy. However, with Covid-19’s appearance, the scenario for all economic activities has changed (Iqbal et al. 2021; Zhang et al. 2021). This led to a study by Honma and Hu (2013) that looked at how the Covid-19 pandemic might affect sustainable energy solutions in the future and now. For the
Covid-19 impact to be addressed, short-term policy objectives must be determined. In addition, both short- and long-term action plans must be devised to meet renewable energy goals effectively and sensibly. Green finance and climate change mitigation nexus research by Alemzero et al. (2021) employed the difference in differences (DID) approach to examine.

Clean energy use, demographic change, carbon emissions, and inflation were all shown to have a substantial impact on the areas’ ability to mitigate climate change through promoting green finance and development in the private sector, according to the conclusions of a study by Tran (2021). Additionally, Anh et al. (2021) evaluated the long-term effects of the current pandemic, Covid-19, on stability and development. While advancement toward the SDGs was insufficient prior to the epidemic, the research found that the financial resources needed to achieve these goals may have been reduced during the outbreak (Zhang et al. 2021; Hsu et al. 2021; Ehsanullah et al. 2021). However, according to the analysis, the replacement of fossil fuel subsidies for renewable energy distribution and expenditure, and a tax increase that finances climate solutions, might better contribute to SDG accomplishment in the Covid-19 pandemic era. To further examine developing nations’ use of green finance mechanisms, Cavallaro et al. (2019) analyzed the best techniques and channels for green economic recovery and promoted environmentally friendly investment.

Tiep et al. (2021) suggested that the current viral pandemic resulted in a rapid drop in energy consumption, which cuts energy prices and slows down renewable energy projects development. There are several opportunities to promote renewable energy, especially in terms of clean power investment. In addition, the authors examined the unique impact of Covid-19 on the global energy market and addressed sustainable energy policies. According to Mohsin et al. (2021b), urbanization activities such as high-speed rail contribute favorably and considerably to green finance and green productivity. This investment’s beneficial impact grows and then decreases gradually. Some studies solely looked at the green in addition to the previous research that studied Covid-19.

Although several studies have examined the influence of fiscal spending in reducing pollution, the academic world has yet to determine the link between fiscal imbalances and green economic growth, and the function of green fiscal imbalances in the E-7 economies. This study utilized empirical research to attempt to fill the gap.

3 Methodology

3.1 Data and indicator measures

The study estimated the nexus between fiscal spending, fiscal disparities, and green economic growth to draw the intended inference. However, respective economic indicators have been used to operationalize through such study methodology. From these indicators, fiscal disparities include GDP (US dollars), vertical fiscal imbalance, change in interest rate into a percentage, foreign direct investment (US dollars), fiscal decentralization, R&D into the GDP percentage. The first features of a green economy were determined using quantitative research and then analyzed the relationship between a
sustainable future and a sustainable economy. To estimate the nexus between the study indicators OLS estimation technique was applied, and the data was taken from 2010–2019. More so, the study investigated the E-7 countries of the world.

3.2 Estimation technique and model

The OLS technique was operationalized to estimate the study findings. For OLS, the directions are taken from Hansen (1996), which provided extended guidance. Such guidance included the minor and transitional databases to test the connection between the constructs. Thus, the OLS technique is extra resistant for all the models including model’s enormous errors. This technique has different styles to predict the yield with uniform variance and real OLS in topical conditions. It also helps to address the common errors in the study sample and provides a valid inference criterion to estimate the nexus between research variables. However, Hansen (1996) introduced the 1st level asymptotic competence model to test the study indicators with the OLS technique. Our study also considered this 1st level asymptotic OLS technique. On OLS, as being specific, the following equation explains the subject-matter, where, for every $i$th aside of a random N trial (Phan et al. 2020):

$$E[m_i(\gamma(\theta))] = 0.$$  

(1)

Temporarily, a partial stricture unit is named with $\gamma$ that is actually emphasized under the Eq. (1). Moreover, this is made-up with equivale entre solution that really occurs and is shown with $\hat{\gamma}$ in Eq. (2);

$$\frac{1}{N} \sum_{i=1}^{N} m_i(\hat{\gamma}) = 0.$$  

(2)

Considering the Eq. (2) in the conception, this equation is transformed into Eq. (3) and is represented with $\hat{\gamma}$. It is converted into Eq. (3) to have a weighted index for a random solution and to pursue the empirical estimation of study indicators with OLS. Equation (3) is as follows,

$$\min_{\gamma} \sum_{i=1}^{N} m_i(\gamma) \left( \sum_{i=1}^{N} m_i(\hat{\gamma}) m_i(\hat{\gamma})' \right)^{-1} \sum_{i=1}^{N} m_i(\gamma).$$  

(3)

Additionally, an inadequate structure of indicators’ measurement, which is shown with $\gamma$, is further transformed into Eq. (4) to acquire the robustness in study estimation and develop a true parameter that must be free from systematic errors. Equation (4) is as follows and is subjugated with $\theta$ in Eq. (4).

$$\min_{\theta} \sum_{i=1}^{N} m_i(\gamma(\theta))' \left( \sum_{i=1}^{N} m_i(\hat{\gamma}) m_i(\hat{\gamma})' \right)^{-1} \sum_{i=1}^{N} m_i(\gamma(\theta)).$$  

(4)
To measure the distinctive two-step OLS, Eq. (4) is transmuted into Eqs. (5), (6), and (7), which is as follows, 

$$
\left( \sum_{i=1}^{N} m_i(\gamma(\tilde{\theta}))m_i(\gamma(\tilde{\theta}))' \right)^{-1}, \tag{5}
$$

$$
B_G = -(G'\Omega^{-1}G)^{-1}E[G_i'P_g_i]/N. \tag{6}
$$

In which, 

$$
G_i = \frac{\partial m_i(\gamma_0)}{\partial \gamma} \frac{\partial \gamma(\theta_0)}{\partial \theta}, G = E[G_i], \Omega = E\left[ m_i(\gamma_0)m_i(\gamma_0)' \right]. \tag{7}
$$

Equations (6) and (7) are extended to use for imitations estimation and test a two-step OLS (Koh et al. 2020) results via Eq. (8) and Eq. (9).

$$
\min_{\theta_i} \left( \sum m_{ii}^{LCM}(\theta_1)' \left( \sum m_{ii}^{LC}(\theta_1)m_{ii}^{LC}(\theta_1)' \right)^{-1} \left( \sum m_{ii}^{LCM}(\theta_1) \right) \right). \tag{8}
$$

If the average contingent criteria are valid, then BG is equal to 0.

$$
m_{ii}^{LCM}(\theta_1) = m_{i1}(\hat{\gamma}) + \frac{\partial m_{i1}(\hat{\gamma})}{\partial \gamma} (\gamma_1(\theta_1, \hat{\gamma}_2) - \hat{\gamma}_1) \quad \text{and} \\
m_{ii}^{LC}(\theta_1) = m_{i1}(\hat{\gamma}) - \left[ \sum \frac{\partial m_{i1}(\hat{\gamma})}{\partial \gamma_2} + \sum \frac{\partial m_{i1}(\hat{\gamma})}{\partial \gamma_1} \frac{\partial \gamma_1(\theta_1, \hat{\gamma}_2)}{\partial \theta_2} \right] \left( \sum \frac{\partial m_{i2}(\hat{\gamma}_2)}{\partial \gamma_2} \right)^{-1} m_{i2}(\hat{\gamma}_2). \tag{9}
$$

Hence, using the two-step OLS technique, till Eq. (9), the study results were estimated and were reported in the next section. For this, the econometric model format is as follows, 

$$
Y_{it} = \alpha_i Y_{it-1} + \beta FS_{it} + Y_{it} X_{it} + \delta_i FIB_{it} + v_i + \mu_t + \epsilon_{it}, \tag{10}
$$

where $Y_{it}$ is shown as the dependent variable—pronounced as green economic growth, FS is termed as fiscal spending, and FIB is named as fiscal imbalances persisting in E-7 countries. Here, $i$ at $t$ time, is a trajectory presentation production effect of economic development purpose, with $\beta$, $\lambda$ and $\delta$ limitations, and error terms. The has been collected from the relevant ministries of the governments, World Bank Indicators (WDI) for World bank, China energy portal, and Chinese relevant ministries of China, especially the relevant of energy and economics.
4 Results and discussion

4.1 Econometric analysis

This article includes data from E-7 economies for 2010 to 2019. Research begins by describing the GEPI’s inputs and outputs. Among the input variables, labor, capital, and energy \( (E) \) were selected. The total number of workers \( (L) \) indicates the labor. The perpetual inventory technique was used to determine the company’s capital \( (K) \) (Zhang et al., 2021). There was no information found on the city’s overall energy use. According to Li and Xu (2018), energy use is strongly linked to power consumption. The study utilized the total electricity economic growth as a fluid indicator of existing green economic and social development by prior research. Sets of control variables are known as Xit. These are the baseline and are parameters that must be calculated. The individual specific is vi, while the random error term is ut. A conventional linear regression model for dynamic panel data, such as Eq. (6), maybe skewed because of inherent issues in this dynamic panel data model. For panel data with “small \( T \) and big \( N \),” OLS methods were looked into to adjust for any biases by instrumenting the endogenous variables. For descriptive estimates, see Table 1.

Independent variables were eliminated using a differencing approach before the OLS estimate was formed. All lagged terms were used as the instrument variables, which might arise certain issues to the linear interpolation procedure. The first step in the linear interpolation procedure was to remove the individual impact by combining the original equation with the first discretization one, which calculates both equations concurrently. Additional sensors may be added to the System-OLS estimator to significantly increase effectiveness. More efficient than a single step, nevertheless. Furthermore, this estimation method is more effective than a single step. Fernandes and Reddy (2021) bounded adjustment demonstrates correct estimate bias and increases two-step robust estimates’ productivity. The OLS estimate was used to accommodate Windmeijer’s adjustment. This

| Study indicators                              | 2010–2014 |            | 2015–2019 |            |
|----------------------------------------------|-----------|------------|-----------|------------|
|                                              | Median    | SD         | Median    | SD         |
| Fiscal disparities                           | 1.07      | 1.68       | 1.01      | 3.29       |
| GDP (in US dollars)                         | 3.44      | 4.53       | 6.24      | 3.61       |
| Vertical fiscal imbalance                    | 3.13      | 2.01       | 2.04      | 10.1       |
| \( \Delta \) in interest rate (in percentage)| 2.11      | 6.17       | 4.34      | 5.45       |
| FDI (in US Dollars)                         | 2.21      | 3.09       | 5.91      | 4.71       |
| Fiscal Decentralization                      | 5.00      | 0.22       | 4.41      | 3.89       |
| R & D Expenditure (in percentage of GDP)     | 3.67      | 4.99       | 3.02      | 1.38       |
| Fiscal spending                              | 2.89      | 2.03       | 4.67      | 4.36       |
| Green economic growth (green growth rise in GDP) | 1.01      | 1.43       | 2.01      | 2.33       |
model incorporated SI, PFDI, GDP per land area, PPS, and the percentage of urban green space that is used by private businesses and identifiable persons. The monetary system, structural changes, and commercial trade all have a role in the inclusion of the first three elements. Every control variable’s range is 2006–2016 since the GEGI spans from 2006 to 2016. Logarithmic representations are employed for all data except for GEGI. The Chinese City Statistics Yearbook, complemented by city-level data catalogs, provides the raw data for this study.

The qualitative data for the major analysis are presented in Table 2. China’s average green economic efficiency is 0.876, as indicated in Table 3. These results are 3.867 for the overall measure, 3.564 for financial inclusion’s breadth, and 5.123 for the profundity of financial inclusion’s complexity. It is also worth noting that both the overall and depth/breadth sub-indexes have large standard variances, suggesting that financial inclusion is not incredibly common across regions. Also, it is important to note that measures with good overall variations, such as global management, government stimulus, and the relationship between economic growth, also exhibit substantial spatial heterogeneity in macroeconomics indicators. Therefore, our econometric analysis relies on selections from a certain time, or even from 2010 to 2018, as used in the efficiency estimate portion.
In the end, 1023 samples were collected after 69 instances with incomplete data for interaction terms were removed from the data set.

Current research suggests that financial turbulence leads to depressions in developed economies, generating greater 10–15% production losses. In addition, the restoration time is longer than when irregularities in the banking system do not bring on a recession. The authors argue that this is due to many factors, including the severity of the economic meltdown, economy-wide disruption, and economic pressures (Pham et al. 2020; Nasir et al. 2019). The Financial Crash may be seen as a defining moment in the research population’s involvement in financial-real business relationships because the annual amount of literature regarding the subject began to rise rapidly in 2006. Prior research heavily concentrated on the impact of bond yields on the productive sector and the resulting changes in agencies’ financial statements on macroeconomic variables in economic growth (Nguyen et al. 2021; Huynh et al. 2020; Chen et al. 2021; Bekiros et al. 2016).

4.2 Fiscal spending analysis

Recent evidence has shown that the complicated impact of the economy and real economies is not always caused by the monetary transmission mechanism, since swift banking system improvements that are not intrinsically related to financial markets also have a significant influence on financial groupings (Balcilar et al. 2016; Jia et al. 2021). According to the data shown in column (1)–columns (2) and (3)–column (4), fiscal R&D expenditure and education investment have an impact on GEGI. The findings of the Fixed Effect model may be seen in columns (1) and (3). Because of this potential for bias, Panel Regression is suggested for individual comparison. No second-order autocorrelation was found by Hansen, and the AR (2) test accepted the null hypotheses, indicating the correctness of framework estimation. For fiscal R&D, all models produced positive and statistically significant effects of at least 5%, while only System-OLS estimation yields positive coefficients for fiscal education expenditure of at least 1%. The OLS technique estimated fiscal R&D expenditure at 0.044 and funding for education at 0.084, respectively. OLS estimations were used as a starting point for future investigation.

The effect of financial leverage on financial performance cannot be overstated. Although Schumpeter (1911) first proposed the connection between financial inclusion and economic expansion, it has since been corroborated by Kalkbrenner (2019) and Ding et al. (2020). Limited research has tried to examine if the various financial developmental pillars from financial services to equities to investments to insurance all have distinct implications for the economy. As a result, it was possible to examine how various kinds of direct investment influence economic expansion-breaking apart foreign investment. The availability of credit directly impacts on aggregate demand since it is a critical determinant of business advancement. It enables families to better manage their spending, save more money, and build up their employee engagement. By giving companies access to commercial, financial institutions required to fund their cash reserves or protracted expenditures, financial inclusion helps foster sustainable growth via financing instruments (Honrubia-Escribano et al. 2016).
This allows companies to create enterprises, which accelerates economic growth. Overall, inclusive growth benefits financial activity because of the factors listed below. Having a materially positive impact on profitability and use of credit facilities (Cossu et al. 2020), which leads to increased earnings, a more resourceful incentive to invest, excessive amounts (Ji and Zhou 2020), a strong cash credit framework for financial institutions, continued improvement in investment decisions (D’Adamo et al. 2020; Campoccia et al. 2014), and better overall execution of meta schemes (Corwin and Johnson 2019; Coria et al. 2019). Results in Table 4 shows that this is a fact that other findings revealed a negative link between financial participation and improved infrastructure in the US (inverted U-shaped) (Qian et al. 2020).

According to Fig. 1, this is in line with the overall trend. E-7 economies’ environmental regulations are known for their “1-year easing and 1-year tightening”

**Table 4** OLS estimation of findings

|                              | One step (1) | two-step (2) | One step (3) | Two-step (4) |
|------------------------------|--------------|--------------|--------------|--------------|
| Fiscal Disparities           | 0.469*       | 0.045*       | 0.647*       | 0.575*       |
|                             | (0.000)      | (0.000)      | (0.001)      | (0.000)      |
| GDP (in US Dollars)          | 0.231*       | 0.128*       | 0.358*       | 0.763***     |
|                             | (0.000)      | (0.000)      | (0.010)      | (0.000)      |
| Vertical fiscal imbalance    | 0.117*       | 0.078        | 0.043**      | 0.432*       |
|                             | (0.000)      | (0.001)      | (0.000)      | (0.000)      |
| Δ in interest rate (in percentage) | 0.562**     | 0.071*       | 0.362*       | 0.447*       |
|                             | (0.004)      | (0.020)      | (0.000)      | (0.000)      |
| FDI (in US Dollars)          | 0.179        | 0.051*       | 0.637        | 0.784        |
|                             | (0.000)      | (0.000)      | (0.002)      | (0.000)      |
| Fiscal Decentralization      | 0.439*       | 0.444*       | 0.707*       | 0.221*       |
|                             | (0.000)      | (0.000)      | (0.004)      | (0.000)      |
| R & D Expenditure            | 0.495*       | 0.287**      | 0.682*       | 0.904**      |
|                             | (0.001)      | (0.000)      | (0.000)      | (0.000)      |
| Fiscal Spending              | 0.247*       | 0.564        | 0.836**      | 0.417        |
|                             | (0.003)      | (0.000)      | (0.000)      | (0.000)      |
| Green Economic growth        | 0.128**      | 0.138**      | 0.236*       | 0.339*       |
|                             | (0.004)      | (0.000)      | (0.030)      | (0.000)      |
| Adjusted R²                  | 0.94         |              | 0.96         |              |
| Arellano-bond AR(1)          | −3.004       |              | −2.959       |              |
|                             | [0.001]      |              | [0.003]      |              |
| Arellano-bond AR(2)          | −0.607       |              | −0.367       |              |
|                             | [0.529]      |              | [0.413]      |              |
| Sargan test                  | 201.99       |              | 274.101      |              |
|                             | [0.894]      |              | [0.877]      |              |

*p value in brackets and standard errors in parentheses; *p < 0.1, **p < 0.5, ***p < 0.01
features. As a result of this “political tournament,” environmental regulation has been inconsistent, and major environmental issues have arisen (Li et al. 2018). There will still be a “political tournament” for a length of time despite the central government’s implementation of several mandated energy conservation and emission reduction initiatives. Thus, the negative coefficient may be attributed to intermittent environment protection.

This study suggests that the compositional impact and the method effect will vary depending on how rich a city’s resources are. The following are the reasons: (i) A lack of human capital and a poor link connecting resource-based business and knowledge and technology transfer will result from a lack of human capital in resource-based cities; (ii) resource-based cities have a single industrial structure, resulting in a lack of innovation from businesses because of the lack of innovation in the resource sector. Therefore, the composition impact and the technique effect may be modest in resource-based cities. As a proxy for a city’s abundance of resources, we split all cities into two categories based on the number of workers in the extractive industry.

4.3 Analysis of regional differences

The coast fared the greatest out of the areas studied throughout the research period. With a well-organized economic structure and a greater degree of resource utilization effectiveness, the northeast coast seems to have been America’s economic and investment powerhouse for over a century. A city on the northern shore with a strong municipal government had a technical efficiency of more than one throughout the research process, placing it first among the Northeast regions. Using control factors that may impact on our original results, they were re-examined using the regression analysis. Broadband innovation has been particularly included since its development.

According to the previous research, financial inclusion can boost the economy. Although several nations are establishing green economic policies and legislation in the age of environmentalists, very little analysis has been conducted on the connection between financial intermediation and the sustainability of the green economy. For this reason, this article aims to explain the relationship between financial
intermediation and green economic efficiency to improve global resource management and further the green economy (Table 5). Financial inclusion and product expansion, particularly in green economic efficiency, could be seen to have a conceivable influence on green economic efficiency by analyzing results. However, in concepts of its exact dimensions, little research has empirically recognized the role of bank participation in green economic efficiency. Fine details of how financial deepening impacts green economic efficiency, particularly for hazardous companies, are little understood. As a result of this reasoning, the first assumption is reached. Capital mentorship mechanisms are required to regulate and control bank lending accurately, which shrinks the conduit for serious companies to receive money, as per Rosman et al. (2014). Large contaminating companies are more likely to change their “environmentally harmful” reputation by cutting energy usage and adopting clean technologies to overcome financing restrictions and decrease expenses when faced with much more serious account balances. As a result, the hypothesis is predicated on the breakdown of green economic efficiency.

4.4 Sensitivity analysis

As follow-up research, this one examined how institutions and human resources in the studied nations interacted to effect fiscal devolution on CO2 emissions. Sensitivity-based econometric model-comparable composite are used in this study to look at the problem from various angles for the reasons already described. The goal of this research was to address the knowledge gap in the academic literature on greenhouse gas emissions and EG to map out a path toward a sustainable economic system. The index’s individual and cumulative impact may help policy-makers, and individual financiers better comprehend the cumulative impacts of finance and energy on a more significant level and make key choices to reduce the hazards of carbon pollution. The results will assist policy-makers in implementing pollution abatement strategies without impeding economic growth. It is a roadmap for policy implementation to reduce pollution’s negative effects. Emission trading systems (ETS) and carbon taxes are two ways in which stakeholders might disperse the benefits of emissions reductions.

In the short-term study, the gross domestic product is closely connected to the delays of the GDP in the (0.05–0.10) percent range. However, at the quantile of 0.60, the influence is no longer substantial, as capital development directly affects EG via the grids of (0.70–0.80). All 11 quantiles of workforce production have a non-significant direct influence on EG. The grids of (0.05–0.30) show how eco-innovation hurts EG. Using the QARDL equation reveals that the figure in Table 6, *, is significant and negative in the (0.05–0.70) range. The growth of the human population has a direct bearing on the highest quartiles of carbon dioxide pollution (between 0.20 and 0.95%). The lowest to medium quantiles of carbon dioxide pollution are directly influenced by per capita income (0.05–0.40). There was a significant reduction in carbon dioxide pollution in the larger quantile (0.80–0.95) attributed to solar energy consumption in this research. According to our findings, indigenous governments will better provide public services as FED rises. This is
| Variables                              | (1)                  | (2)                  | (1)                  | (2)                  | (1)                  | (2)                  |
|----------------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Fiscal Disparities                     | 0.007 (0.001)         | 0.005                 | 0.009 (0.003)         | (0.006)               | 0.002                 |
| GDP (in US dollars)                    |                       |                       |                       |                       |                       |                       |
| Vertical fiscal imbalance              | 0.298 (0.081)         | 0.291 (0.081)         | 0.298 (0.081)         | 0.341 (0.082)         | 0.003                 | 0.001                 |
| Δ in interest rate (in percentage)     | (0.059)               | (0.041)               | (0.059)               | (0.041)               | (0.061)               | 0.001                 |
| FDI (in US Dollars)                   | 0.002                 | 0.003                 | 0.002                 | 0.002                 | 0.002                 | 0.002                 |
| Fiscal decentralization                | (0.079)               | (0.078)               | (0.082)               | (0.081)               | 0.005                 | 0.002                 |
| R & D expenditure                     | 0.039                 |                       | 0.041                 |                       | 0.061                 |                       |
| Fiscal spending                        | 0.211                 | 0.040                 | 0.209                 |                       | 0.241                 |                       |
| Green Economic growth                 | (0.069)               |                       | (0.071)               |                       | 0.131                 |                       |
| Adjusted $R^2$                         | 0.94                  |                       | 0.96                  |                       |                       |                       |
| ARellano-bond AR (1)                  | −3.004                |                       | −2.959                |                       |                       |                       |
| aRellano-bond AR(2)                   | −0.607                |                       | −0.367                |                       |                       |                       |

Table 5 Green economic efficiency analysis-based super efficiency model
| Variables                        | (1)      | (2)      | (1)      | (2)      | (1)      | (2)      |
|---------------------------------|----------|----------|----------|----------|----------|----------|
| SArgan test                     | 201.99   | 274.101  | 0.894    | 0.877    |
| Adjusted $R^2$                  | 0.94     | 0.96     |          |          |
| ARellano-bond AR (1)            | −3.004   | −2.959   | [0.001]  | [0.003]  |
| ARellano-bond AR (2)            | −0.607   | −0.367   | [0.529]  | [0.413]  |
| $N$                             | 1023     | 1023     | 1023     | 1023     | 1023     | 1023     |
| $R^2$                           | 0.037    | 0.040    | 0.043    | 0.036    | 0.038    | 0.041    |
why environmental isolationism has been a major focus for indigenous governments, ultimately improves overall ecological quality.

5 Discussion

When the mechanism analysis is applied, it examines how fiscal expenditure could affect green economic growth. Technological activities and activities requiring a high level of human capital both support green economic development in their unique ways. It is also worth noting that budgetary expenditures play varied functions depending on the kind of resources. We interpret these observations in the following ways: education expenditure has an equal influence on human capital investment in resource-rich cities, which have a large state-owned component (Lee et al. 2020). Most Chinese resource-based enterprises are controlled and monopolized by the government; in spite of this, China’s traditional welfare system ensures greater educational resources for its citizens. There is no reason to believe that a country’s abundance of natural resources would diminish the favorable impact of education expenditure on human capital investment (Samour et al. 2020).

A second explanation is that the resource-rich cities have limited innovation activities and a fixed industrial structure; thus, R&D investment has a minor impact on fostering technical innovation while fiscal spending has a huge impact on upgrading the industry. Hence, it is assumed that companies are now dealing with credit constraints (Chatziantoniou et al. 2021). Enterprises may borrow money from the banking system to cover the gross and net expenses of the green economy. On the other hand, credit restrictions may prohibit them from taking out the maximum amount of debt to cover their costs in the green economy (Hafner et al. 2020; Xie et al. 2021). The issue of maximizing the operating income arises when borrowing a certain amount of revenue and assuming that credit restrictions are in place. When \( m = 0 \), it is simple to see that \( mC = mU \) and that \( mC \) is a diminishing ratio.
in \( m \)'s magnitude. Green economy efficiency is always relatively low under credit constraints, so an enterprise will generate more income for its goods, start producing less output, and receive a lower export financial gain as credit levels fall. This is because green economy efficiency is always relatively low when it is under credit constraints (Yoshino et al. 2019).

6 Conclusion and policy implications

An environmentally friendly economy is essential for long-term growth. In this paper, the nexus of fiscal imbalances, green fiscal spending, and green economic growth: empirical findings from E-7 economies were measured. The link between government expenditure and pollution emissions fails to include the influence of government spending on sustainable economic development. The non-radial direction distance function was used to generate a green economic growth index based on panel data. System-OLS estimate is used to examine the impact of financial education and R&D funding on green economic development in both the whole sample and sub-sample dimensions. Finally, looking at the mechanisms that might have an impact and talk about the fundamental causes. The following are our findings: Green economic growth index shows that this index changed over time with a characteristic of “1-year growing and 1-year declining,” which is ascribed to the “political tournament” of local governments in this research. Scale effects only occur when a specific amount of obstruction is present. However, our analysis concluded that breaching a particular threshold for devolution is the best alternative to choose over ecological funding.

Including a complete indicator into the review process provides a better grasp of the current state of sustainable development and lessens the negative consequences of sporadic environmental regulation. Local governments should focus more on public goods when it comes to fiscal expenditures. Some industrialized nations, such as the United States, spend far more on public goods like R&D and education than others. For example, a shift in government expenditure toward public goods might help to stimulate green economic development. A green economy may be built by shifting the mix of government expenditure and boosting human capital and technology-intensive industries. Additionally, local governments should consider the regional variability by implementing a variety of city-specific development strategies. Fiscal investment positively influences on the economy, but China’s cities are diverse, which must be acknowledged. As a result, various regions need to use various development strategies. The R&D investment and technical activities should be given more priority. More has to be done in the field of fiscal expenditure and green economic development. A more comprehensive index of green economic development might be developed for better understanding.

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