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Impact of non-renewable energy and natural resources on economic recovery: Empirical evidence from selected developing economies

Chenyang Yu [a], Massoud Moslehpour [b,c], Trung Kien Tran [d], Lam Minh Trung [e,*], Jenho Peter Ou [f], Nguyen Hoang Tien [g,h]

[a] School of Economics, Hangzhou Normal University, Hangzhou, 311121, China
[b] Department of Business Administration, Asia University, 500, Lioufeng Rd, Wufeng, Taichung, 41354, Taiwan
[c] Department of Management, California State University, San Bernardino, 5500 University Parkway, San Bernardino, CA, 92407, USA
[d] School of Public Finance, College of Economics, Law and Government, University of Economics Ho Chi Minh City, 59C Nguyen Dinh Chieu, District 3, Ho Chi Minh City, Viet Nam
[e] Faculty of Business Administration, Van Lang University, 69/68 Dang Thuy Tram Street, Ward 13, Binh Thanh District, Ho Chi Minh City, Viet Nam
[f] Department of Finance, Asia University, 500, Lioufeng Rd, Wufeng, Taichung, 41354, Taiwan
[g] Ho Chi Minh City University of Food Industry, 140 Le Trong Tan, Tan Phu district, Ho Chi Minh City, Viet Nam
[h] WSB University in Gdansk, Poland

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ABSTRACT

Panel data examines the effects of renewable and natural resource usage on Green economic recovery in the top 10 nations adopting non-renewable energy from 1975 to 2018. Misunderstandings of sustainable energy legislation are often a result of structural breakout that go unnoticed. Fourier-based approaches are used to examine the nexus of non-renewable energy and natural resources on green economic recovery in selected countries. Economic recovery in eight of the ten nations depends on natural resource development, whereas sustainable energy contributes to economic recovery in Germany, Denmark, and France over the long term. Italy, Malta, the UK, and Greece are examples of countries where the energy-led growth theory holds. Even though Italy's economy relies on non-renewable energy, the preservation theory holds for both power parameters in Germany and sustainable power in China. While non-renewable energy is not as powerful as exhaustible power, the total findings demonstrate that natural resource development has the potential to be a significant driver of green economic recovery. Policies to combat energy ineffectiveness should thus check an overworked world-ecology, reduce urban oddities, and encourage ecological learning for a better atmosphere.

1. Introduction

Economical, ecological, and health issues have afflicted humanity since the dawn of the 21st century. Among these are the 2008 and 2019 pandemic crises, which changed the world's stage. The pandemic has affected activity worldwide, such as those relating to society, economics, and ecology. When this comes to financial and clinical capabilities, developing nations are at a handicap (Moslehpour et al., 2022), but even developed countries aren't exempt from crises in such areas(Saghiri et al., 2017). believe that the economic crisis exasperates an already unpredictability of environmental assets and has far-reaching effects on the nation's micro and macro sectors. Vital to the health of the economy and its people, the connection between natural assets and economic growth is an area often overlooked yet vital to understanding. Group of Seven (G7) economies also feel the effects of the socioeconomic repercussions and are trying hard to return to normal. Especially in this age of globalization, when sample surface is being decreased and borders among nations are now being eliminated, the major distress of numerous discourses is weather variability and climate change as a comprehensive threat(Nardo, 2020). The depletion of natural resources mostly causes global warming due to economic expansion. Since 2007, natural resource extraction has grown from 7 billion tons to 16 billion tons. Biomass output has expanded from 10 billion to 25 billion metric tons, while mineral resources have expanded nearly six times in the same period as bioenergy(S. Y. S. E. Barykin et al., 2021) was devised to conquer the number of greenhouse gases (GHGs) that significantly add

* Corresponding author.
E-mail addresses: yuchenyang@hznu.edu.cn (C. Yu), writetodrm@gmail.com (M. Moslehpour), kientt@ueh.edu.vn (T.K. Tran), Trung.lm@vlu.edu.vn (L.M. Trung), yukl@asia.edu.tw (J.P. Ou), tiennh@hufi.edu.vn (N.H. Tien).

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to atmosphere variations as a consequence of this global warming and is recognized as a calamity (emergency). In force since 2005, the approach described lowers emissions from six GHGs in 41 countries and European Union (EU) countries to 5.2% below 1990 levels over the "commitment period," or years 2008–2012. Carbon dioxide emissions (CO2) contribute to an increase of around 58.8 percent in climate change and climatic variations globally(Lu et al., 2020). In particular, the Paris accord of 2016 to limit emissions of greenhouse gases expands on the foundation established by the Bali protocol to fight climate change. To achieve these goals, all member states (also called associate states) have accepted this declaration, which is the final step of the process and proves their dedication to fighting global warming and climate change. It's heartening that there is a such wide agreement regarding 2016's classification as the hottest year ever recorded for earth. HCFCs (CFCs), water vapor (H2O), methane (CH4), nitrous oxide (N2O), and carbon dioxide (CO2) are all pollutants that lead to global warming and climate change(Hossain et al., 2020). Emissions of co2 produce almost 81% of the overall GHGs. An increase in the carbon impact is often attributed to the rise of the financial sector, the exploitation of natural resources, globalization, and the use of energy from fossil fuels(S. E. S. Y. Barykin et al., 2021).

An organization's economic development and health are key contributors to the finance sector's knowledge. It also has a physically powerful role to play in fostering economic growth. Decreasing the investment barriers and demanding less work from monetary backing promotes trust amongst investors and consumers, enabling businesses to expand and pushing clients to spend more on high-priced seats. However, there is a price to pay to receive such advantages from the modern banking markets(Matsuda et al., 2019). There has been a plethora of research that has found and examined the deep relationship between both the advanced finance industry and enviro deficit(Pilipenko et al., 2019). This happens because a developed financial sector allows for more effective utilization of energy usage with strong technological offerings and endorsement of enviro security standards with minimum cost and maximum funds(Cai and Lo, 2020). Epidemiological research has estimated conflicting results for developing and developed nations. Inside the context of a weak (insignificant) link between economic development and environmental decline(Hajdas et al., 2022), the findings of a few studies are very perplexing. For example, a flourishing financial sector can help companies conquer planned hurdles and achieve scale economies in the production sector's process, resulting in lower environmental pollution formation. One alternate theory examines the possibility that the financial model could promote the entrance of conventional, filthy, conventional, and wasteful sectors that are thought harmful to air sustainability. The findings of the existing literature are thus quite conflicting, requiring more exploratory examination to paint a clear depiction of reality.

According (Herrero, 2017), using the Fourier ARDL and Fourier TY techniques, they examined the impact of energy use on the environmental footprint. It is important to note that none of this research explored the relationship between energy use and financial development. This is where we diverge from previous research (Gouveia et al., 2019).

This research has important implications for gauging the impact of non-renewable energy and natural resources on economic recovery. Political instability is bad for businesses: it disrupts the financial system and slows the economy. When politics are stable, the productivity of economic factors rises. There are simulated area plots where 20 percent of the projected factors experience beneficial or harmful surprises from the DARDL analysis. As a result, the current research closely examines the nexus in developing economies using data from 1995 to 2018. Secondly, the research evaluates the function of natural resource utilization, gross capital creation, and non-renewable energy consumption in the relationship between resource rents and economic recovery. Furthermore, the developing economies and the importance of non-renewable energy and natural resources are analyzed. However, in developing nations, economic recovery is somewhat bolstered by using non-renewable energy and the instability of natural resources. Because of this, the report suggests a few policy ramifications that might improve the developing economies' economic recovery. Since carbon dioxide (CO2) emissions are detrimental to environmental sustainability, rules limiting their production should be updated. As such, non-renewable energy sources may provide a more practical solution for integrating and sustaining EP and environmental quality. Economic recovery is also lower when natural resource instability is present. As a result, smooth economic recovery requires stability in natural resources via methods like price ceilings and price fixing to mitigate the effects of supply and demand disturbances in the natural resource market. To fill the void, this research examines how various non-renewable energy sources impact Carbon emissions and long-term growth. (2) Previous studies have only independently addressed the impact of natural resource utilization and non-renewable energy resources on carbon emissions and environmental sustainability. Both are considered in tandem as potential drivers of carbon emissions in our investigation. Thirdly, we take a fresh look at developing economies' weather and economy to gauge the effects of natural resources and non-renewable energy sources on greenhouse gas emissions and long-term growth.

The remainder of the paper is organized in the following way; a literature review of non-renewable energy and natural resources development on economic recovery is discussed in section 2. The theoretical framework of natural resources' impact on green economic recovery is presented in section 3. Data and methodology are presented in section 4. Results and discussion are presented in section 5. The last section contains the conclusion and policy implications.

2. Review of literature

In this era of rapid economic growth, the world economy has a significant challenge in ensuring environmental sustainability. A nation's resources are an asset to its economy almost all over the globe. Nations in the developing World may now profit from their asset and tall industries. The ecosystem is harmed due to careless use of assets and the growth of rents from those sources. In industrialized countries, charcoal, gasoline, and petroleum are the major sources of environmental damage (Zhabko et al., 2019). Nations rich in coal, gasoline, and petroleum restrict national financial ability to the "resource curse" phenomenon. When the "resource curse hits a nation's economy," it often suffers environmental problems like carbon dioxide emissions(Aslam et al., 2020). The research looked into the link between carbon dioxide emissions and non-renewable energy sources in developing Asian countries. Based on the results, the effectiveness of Emissions of co2 falls as the number of non-renewable energy sources becomes more easily accessible. The Introduction section was verified in its first phases in Malaysia utilizing Fixed Effect Ordinary Least Square (FMOLS) data. These findings indicate that rising natural resource demand is the root cause of a long-term increase in CO2 emissions.

The environment in the G7 economies has deteriorated over time due to economic growth and increased money from environmental assets. Nations aren't doing enough to preserve a pure ecological landscape. Growing financial growth and later regulation of CO2 emissions are also causes of the inversion Shaped theory of the Kuznets Curve of Environment (EKC) in Sub-Saharan African countries. The findings of (Leal and Perez, 2009) indicate that the short- and long-term increase in carbon dioxide emissions among the G7 nations may be ascribed to the general rents from using environmental assets and global economic integration. However, a study conducted in twenty-two developing nations discovered that economic growth and resource rents led to a rise in the carbon impact of these countries. Based on the second carbon emissions paradigm, income activity, resource rents, and urbanization are the final reasons for environmental deterioration.

Environmental destruction and asset rents have been the topics of research. These latest results indicate a clear connection between environmental deterioration and resource rent in developing countries. According to(Lazaris and Vrechopoulos, 2014), green investments and resource rents enable regions in China to ensure sustainable developers maintain a clear goal. The increasing revenue from selling environmental assets has increased carbon dioxide emissions in 30 of China's areas (Marmolejo-Saucedo, 2020). Carbon dioxide (CO2) emissions are discussed as a consequence of the extraction of natural resources in OECD nations. Whenever the ecological footprint and the environmental cost are considered, the value of natural resources is reduced to nearly nothing. Examined the link between the economy of China and the profits made from the nation's natural resources within the context of globalization(Golosnoy et al., 2019). These facts support the resource curse hypothesis, which has been widely criticized for its inability to account for the impacts of economic growth, increases in human resources, and globalization. The findings suggest that globalization and human capital growth are important for Beijing to make more efficient use of its environmental assets(Lee, 2020).

International ecological quality is influenced by both resource rents and the growth of the global economy. Discovering sources of non-renewable energy is important for lowering carbon dioxide emissions. Non-renewable energy is generally recognized as a nil option. It's fascinating to look back at research on sustainable energies and natural asset rents with an eye on reducing CO2 emissions. Brazil, Russia, India, China, and South Africa (the BRICS nations) are all linked in terms of the rent from environmental assets, renewables, economic growth, and Carbon intensity. The availability of natural assets in Russia has resulted in lower Emissions of co2 than in South Africa. China, Russia, and Brazil have discovered evidence to back the EKC theory. The ecological damage of Brics nations is worsened by the profits they earn from non-renewable energy and natural resources. This shows the positive effect on the environment by just using non-renewable energy sources and exploiting natural resources. Economic development's positive and negative effects on ecological footprint have shown the inverted U-shaped EKC hypothesis in BRICS.

All BRICS nations have confirmed their existence, as the nation EKC theory anticipated. Four Chinese regions' mineral wealth is linked to CO2 emissions in those areas. The environmental degradation in Xinjiang and Gansu is even greater than in Ningxia and Gansu. However, Gansu province is responsible for less CO2 emissions. Qinghai and Xinjiang can only confirm the validity of the EKC. Non-renewable energy sources in China are addressing this by reducing carbon dioxide emissions and improving environmental stability. A dynamic panel methodology conducted a study on the link between geopolitical risks and clean power sources. A unidirectional causal link between geopolitical tensions and non-renewable energy is demonstrated by examining subsets. Non-renewable energy development resources should take into consideration geographic hazards.

Demonstrated a direct connection between the use of non-renewable energy sources and the emission of greenhouse gases in six developing nations. The adoption of non-renewable energy has helped reduce Emissions of co2 and improve EKC in OECD countries (Burroughs and Burroughs, 2020). The utilization of renewable sources of energy benefits the economy and the environment of members of the EU. Sustainable economic development and lower CO2 emissions were found in a wide panel of 85 developed and rising economic systems(Podvalny et al., 2017). The usage of non-renewable energy has been found to increase environmental sustainability by lowering CO2 emissions in 42 emerging economies (Pinto et al., 2019) hypothesized that carbon dioxide emissions are negatively connected to renewable power and are also visible in the U-Shaped Environmental Kuznets Curve for India. Highlighted how switching to non-renewable energy sources may assist reduce carbon dioxide emissions. Nevertheless, a rise in the usage of renewable encourages economic progression in the top 30 industrialized nations. Using non-renewable energy sources led to a greener way in European countries. Using non-renewable energy sources helps reduce carbon dioxide emissions in Sub-Saharan African nations. Energy usage patterns, especially renewable and nonrenewable, are addressed in Ref. GDP and CO2 emissions have a causal connection. The EKC reversed U-Shaped hypothesis was supported by regional research in China that examined the influence of non-renewable energy and squared growth in the economy on Dioxide emissions in the Western and Eastern areas. Renewable sources have reduced Carbon emissions per capita, as reported in(Irfan et al., 2021). However, OECD nations' EKCs are U-shaped because economic growth significantly increases CO2 emissions. The Bric nations' use of non-renewable energy decreases their carbon dioxide emissions. In seventy-four nations (Feng et al., 2021), presented proof of the EKC and stated that using non-renewable energy has reduced the pace of environmental degradation. In various cities across the globe, the adoption rate of non-renewable energy sources has led to a 40% reduction in Carbon emissions, as reported in Ref.(Ahmad et al., 2020). Showed that the utilization of non-renewable energy in OECD countries hurts the ecological footprint and that the U-shaped Environmental Kuznets Curve hypothesis does not hold any water in European countries. Some study has already shown that the use of renewable sources of energy slows down environmental deterioration by a negligible amount. Data from 7 countries show that the use of non-renewable energy in Sub-Saharan Africa and the Middle East doesn't contribute significantly to pollutants. If the EKC hypotheses are true, non-renewable energy sources might help lessen environmental damage. Looked into the link between CO2 emissions and economic growth in Turkey and concluded that it is consistent with the U-Shaped theory. Also, switching to non-renewable energy sources has not affected carbon dioxide (CO2) production. Showed that in 19 African countries, using clean energy had no impact on carbon dioxide emissions.

Many studies found a link between renewable power, environmental assets, and environmental degradation in various regions, as shown in this literature review. However, previous research or discussion on the significance of international affairs in establishing such connections is lacking. Consequently, the current focus of the study is on the political aspects of the link between green energy and carbon emission(Chen et al., 2021). The present study's findings are expected to draw attention to the value of diplomatic efforts in the regional development of renewable power and reducing carbon footprints.

Compared to the other nations in the group, Argentina should be generating fewer emissions, as shown by this data. Carbon emissions are influenced by several variables, not only the amount of energy generated from fossil fuels. This means that a country's overall level of carbon emissions may not be solely dependent on its energy output.

3. Theoretical framework

Developmental cities are expanding at an unprecedented rate. The migration of individuals from country regions to cities (urbanization) occurs at various stages of financial expansion and manufacturing structure(Castaño-Rosa et al., 2019). The economic advantages of urban expansion go well beyond creating new jobs and income; they also contribute to expanding existing businesses and industries. According to current civilization in growing countries, industrialization is one crucial building block for assessing national progress(Costa-Campi et al., 2019). Humanity and the environment are being put at risk by the rapid urbanization in emerging nations today. Through smog levels and behavioral alterations, industrialization lowers human life duration and the quality of their lives, and it also alters nature in unexpected ways. According to (Castaño-Rosa et al., 2020), financial growth depends on the expansion of metropolitan areas and commercial areas. Both industrialization and development are important parts of modernization, according to(Castaño-Rosa and Okushima, 2021). There is a direct correlation between financial progress and modernization and increased energy consumption in emerging nations because of industrialization and industrialization (González-Eguino, 2015). This data shows that scholars are excited about the energy requirement effects of urbanization and industrialization in emerging nations. These nations are expanding and depending heavily on large energy consumption, a big wild card in the globe's energy requirement estimates because of the rapid rise of population and industrialization (Bienvenido-Huertas, 2021). Cities use 80percent of the country's overall energy output and emit an equal amount of carbon in the atmosphere. As a result, urban finance and environmental policy now prioritize industrialization and population growth (Bornmann et al., 2008). According to (Bouzarovski, 2017), city regulations are essential to regulate rapid urbanization. Decision-makers in emerging nations will have an easier time increasing power conservation and mitigating environmental transformation once the urban expansion is under control. Better urban and commercial planning, on the other hand, might have an impact on energy saving and climate change prevention efforts(Barnes et al., 2011). Understanding the relationship between urbanization, industrialization, and energy demand are important when reducing energy consumption in emerging nations. Before conducting a critical review of current empirical research, it is necessary to establish a conceptual platform on the impacts of gentrification and industrialization on energy use.

The study's second goal is to examine the effects of natural resources on the ecological footprint. Resources with a smaller carbon impact, such as agricultural land, forest land, cultivated territory, fishing waters, and pasture area, help offset carbon emissions from anthropogenic activities and provide required input material for power stations (Sun et al., 2019). Yet, many traditional resources negatively impact the environment's performance (Fargnoli, 2020). Natural resources, however, have also been found to have a strong correlation with a country's pro income per capita. At the beginning of economic growth, individuals frequently overlook the environmental consequences of increasing their use of nonnon-renewable energy sources such as environmental assets. Here is a less urgent need to clean the surroundings, protect environmental assets, and produce power goods in the early stages of economic growth while people's quality of life is still relatively low. Furthermore, a higher GDP per capita means more natural resources will be exploited, more industrial output will be created, and crop yields will rise, all of which contribute to a faster pace of natural resource depletion(Molla et al., 2019).

Nevertheless, the increasing rate of depletion of natural resources due to farming, quarrying, and forestry could have a paradoxical impact on environmental quality(Durán-Romero et al., 2020). Overuse of "ecological yields and environmental assets" has a similar impact, pushing countries toward fuel methods that are more efficient financially but have a larger negative effect on the environment. To speed up environmental damage, the level of biodiversity is decreased when mineral wealth is being used up(Silva and Henriques, 2021). Therefore, it's essential to look into variables such as economic growth, environmental assets, globalization, nonrenewable and non-renewable energy use, and environmental imprint. These interactive features will help businesses shift from nonrenewable (fossil fuels) to sustainable (modern and cleaner) energy industries and will also lead central governments and politicians.

To reexamine the contaminant smog purpose and create the quality of the environment for asset countries, the existing research integrates the globalized index (an aggregate of social, financial, and diplomatic factors related to globalization) and sustainable energy and quasi energy usage. Despite this, Jones described globalization as interweaving various parts of society via greater communication and interaction. On the other hand, define it as a multifaceted phenomenon that includes interactions between individuals and organizations across national borders in social and technological development, economy and culture, and environmental issues. Trade and FDI among member countries promote economic growth, development, energy demand, and transparency. Increased human stress on the ecosystem is a direct consequence of a country's economic internationalization and inclusion, which both lead to an overwhelming ecological imprint(Abid et al., 2021). The planet's condition has improved, but views are different on the importance of this shift.

4. Data and methodology

Renewable and Natural resource development and green economic recovery are examined in the top 8 non-renewable energy-consuming nations, such as Slovenia, Malta, Sweden; Denmark; Romania; Greece; Estonia, Poland; Ireland; and Slovenia. 7.68% of the world's non-renewable energy consumption will be sourced from these nations by 2020 (Tamazian et al., 2009). It is set from 1975 to 2020 since Sweden's GDP has been known since 1971. Parameters and their assets are shown in Table 2. Information was gleaned from the World Bank and Data on the World's Peoples databases. Logarithmic transformations are done to all variables before their inclusion in the study. Panel unit root, cointegration, and cause tests, involving estimation are used to investigate short- and long-term correlations between factors (see Table 1).

4.1. Model specification

When examining the stationarity of indicators or present correlations among variables, it is important to consider structural discontinuities in the data collection process (Shafik and Bandyopadhyay, 1992). The use of fake factors is one method of detecting fundamental breakdowns. As Hyndman explains(Adams and Klobodu, 2018), "most objects alter gradually over time," This approach has been criticized since it can only catch dramatic shifts. The Fourier function provides several smooth transitions in this research, which is why panels are used.

4.1.1. Panel fourier stationarity test

Using fake factors and an extension of (Grossman and Krueger, 1992) test, (CBL) bring a novel panel stationarity test into the research (Rasoulinezhad, 2020).added a function to the analysis of the panel test to account for fundamental alterations that fake factors cannot capture. This newly suggested test is employed in our investigation. It has several desirable qualities, including soft building breakdowns in contrast to acute breaks and allowing for dependency and variability in the cross-sectional area. There are also structural alterations that are determined endogenously. To apply (Yoshino et al., 2021) 's panel stationarity test, we utilize the following test regression: How much does the overall power usage in the nations rise when more people move into urban areas in equation (1).

$$LNENGPC_{it} = \alpha_0 + \beta_1 LNURB_{it} + \beta_2 LNPER_{it} + \beta_3 LNSER_{it} + \beta_4 LNGDPC_{it} + \beta_5 LNEGI_{it} + \beta_6 LNIVA_{it} + \varepsilon_{it} + v_{it} \quad (1)$$

Is there a correlation between population and academic levels and non-renewable energy usage in economies of Eqs (2)–(5)

$$LNGAS_{it} = \alpha_0 + \beta_1 LNURB_{it} + \beta_2 LNPER_{it} + \beta_3 LNSER_{it} + \beta_4 LNGDPC_{it} + \beta_5 LNEGI_{it} + \beta_6 LNIVA_{it} + \varepsilon_{it} + v_{it} \quad (2)$$

$$LNCOAL_{it} = \alpha_0 + \beta_1 LNURB_{it} + \beta_2 LNPER_{it} + \beta_3 LNSER_{it} + \beta_4 LNGDPC_{it} + \beta_5 LNEGI_{it} + \beta_6 LNIVA_{it} + \varepsilon_{it} + v_{it} \quad (3)$$

$$LNGAS_{it} = \alpha_0 + \beta_1 LNURB_{it} + \beta_2 LNPER_{it} + \beta_3 LNSER_{it} + \beta_4 LNGDPC_{it} + \beta_5 LNEGI_{it} + \beta_6 LNIVA_{it} + \varepsilon_{it} + v_{it} \quad (4)$$

Do population and educational attainment have an impact on the use of non-renewable energy in the

$$LNRE_{it} = \alpha_0 + \beta_1 LNURB_{it} + \beta_2 LNPER_{it} + \beta_3 LNSER_{it} + \beta_4 LNGDPC_{it} + \beta_5 LNEGI_{it} + \beta_6 LNIVA_{it} + \varepsilon_{it} + v_{it} \quad (5)$$

Energy use per person ($LNENGPC_{it}$), use of oil and other fossil fuels ($LNOIL_{it}$), use of coal and other fossil fuels ($LNCOAL_{it}$), and use of normal gas and other non-renewable energy sources ($LNGAS_{it}$) are some

Table 1
Data description.

Data	Symbol	Definition	Measurement unit	Source
Gross domestic production	GDP	A country's GDP is the total output of all its residents, less taxes and subsidies.	Constant 2010 US $, per capita	World Bank
Non-renewable energy consumption	REC	Biofuels, wind and solar, hydroelectric, solar, wave and tidal, and wind are all included in REC.	kWh, per capita	World development indicator
Natural resources rent	NNR	Income from the recovery of a natural resource is known as natural resources rents, and they are calculated by taking into account the cost of extracting the resource. This group included oil rents, natural gas rentals, coal rents, mineral rents, and forest rents.	% GDP, per capita	World Bank

Table 2
Results of Cross-sectional dependence and homogeneity.

Panel (a) Cross-sectional dependence	CD stat. Pesaran		LMadj-stat Pesaran et al.	
Variables	Test stat	p-value	Test stat	p-value
lnGDP	51.339*	0.000	41.877*	0.000
lnREC	51.241*	0.000	17.489*	0.000
lnNNR	51.390*	0.000	50.969*	0.000
Panel (b)Slope homogeneity Models	Pesaran and Yamagata Δˆ statistic	p-value	Δˆadj statistic	p-value
GDP = f(REC)	29.607*	0.000	29.581*	0.000
GDP = f(NNR)	49.459*	0.000	49.050*	0.000
GDP = f(REC,NNR)	22.861*	0.000	41.270*	0.000
REC = f(GDP,NNR)	39.239*	0.000	39.961*	0.000
NREC = f(GDP,REC)	61.678*	0.000	61.051*	0.000

of the models' predicated variables ($LNRE_{it}$). Urbanization (LNURBit), elementary learning (LNURBit), secondary schooling (LNSERit), financial expansion (LNGDPC), and economic recovery are all included on the right-hand side (LNIVAit). The stable term is 0, while the slope factors range from 0 to 6. Fixed-effects analyses, nation, and constant temporal influences, and the mistake term is vit.

5. Empirical results and discussion

The factors' minimum and greatest numbers, variance and standard deviation, and implies are all shown in Table 2 as part of the descriptive analysis. Overall, the average NRR was 0.190, and the average REP was 22.249 among 133 data used in this analysis (7 nations x 19 years). The data also showed that, on average, the REC was 10.561, and the CRW was 3.088. Finally, the average EG value was 1.408, and the average PG value was 0.477.The study also examined the observed countries' descriptive data (See Table 3). The study revealed that Japan had the smallest NRR (0.005%) while Canada had the greatest (0.697%). However, whereas The Us had the lowest REP value (10.812%), Canada had the highest RESP value (61.510%). The Uk had the lowest REC (4.748%), while Canada had the highest (22.055%). Furthermore, Japan had the lowest CRW at 0.876%, while Canada had the most at 4.426%. Values for EG varied from 0.220 in Italy to 2.571 in Canada. Finally, PG was least (0.024%) in Japan and highest (1.069%) in Canada. Further, descriptive analyses are presented in Table 4 for each year. Highest NRR was determined as 0.521% in 2019, with 2017 showing the worst NRR at 0.019%. While in 2019(Zhu and Qin, 2019), it reached a record high of 29.030%, the worst return on investment (REI) was recorded in 2003 at 16.524%. Results also showed that the lowest REC was observed in 2001 at 7.054% and the highest at 14.182% in 2019. Moreover, the lowest CRW was reported in 2001 at 1846%, and the highest was reported in 2019 at 4.064%. This is followed by EG, which had a low of 4.160% in 2009(Chien et al., 2021) and a high of 2.783% in 2007. Finally, in 2011, the PG was at its low (0.158%) and greatest (0.556%) since 2008.

According to the significant level of the CD test data, there is proof of cross-sectional dependency in the data sequence in Table 3. For this reason, we have used two different ways to overcome the issue, namely Panel Corrected Standard Error (PCSE) and Feasible General Least Squares (FGLS) estimates, to assure no bias in our predicted variables using the typical panel econometric model approximation. Two approaches are used to generate predicted outcomes. On the other hand, research shows a long-term, imbalanced link between NRR and REC. Technology has made it possible to transform the original industry into one that is environmentally friendly and creates little or no pollution. This means that the government should educate the population on employing sustainable practices and green technologies in everyday life to achieve maximum economic recovery with the least negative influence on the environment. We've established that the long-term

Table 3
Results of Panel Fourier stationarity test (PFST).

Panel (a): country-specific results									
Variables	lnREC			lnNNR			lnGDP		
Countries	Test-stat.	5% CV	F-stat	Test-stat.	5% CV	F-stat	Test-stat.	%5 CV	F-stat
Denmark	0.019	0.041	49.149*	0.150	0.050	7.406*	0.061	0.022	180.741*
Greece	0.204	0.071	3.051	0.121	0.070	69.888*	0.121	0.039	6.231*
Ireland	0.079	0.022	3.861**	0.361	0.029	14.850*	0.131	0.081	0.690
Malta	0.041	0.041	159.821*	0.188	0.029	17.514*	0.191	0.049	31.351*
Romania	0.051	0.031	12.990*	0.190	0.029	50.544*	0.031	0.041	22.769*
poland	0.049	0.103	13.669*	0.180	0.041	5.077*	0.070	0.041	16.131*
Slovakia	0.031	0.050	4.640*	0.056	0.029	17.305*	0.141	0.042	14.280*
Sweden	0.105	0.070	5.522	0.104	0.051	81.955*	0.018	0.060	39.206*
Slovenia	0.019	0.059	8.041*	0.170	0.041	16.241*	0.329	0.088	131.918*
Estonia	0.115	0.031	15.107*	0.122	0.031	255.861*	0.039	0.071	152.171*
Panel (b): Group results									
	Test stat		p-value	Test stat		p-value	Test stat		p-value
Homogenous long-run variance	0.788		0.213	8.390		0.000	−1.171		0.881
Heterogeneous long-run variance	2.450		0.000	13.490		0.000	4.680		0.000

Note: * and ** denote significance at 1% and 5% levels, respectively.

Table 4
Results of PFCT

Panel (a): country-specific results							
Empty Cell	GDP = f(NNR)		Empty Cell	Empty Cell	GDP = f(REC)		Empty Cell
Countries	Statistics	1%	k	Countries	Statistics	1%	k
Denmark	−2.339*	−3.661	1.700	Denmark	−2.372*	−2.288	1.200
Greece	−4.261*	−3.959	1.200	Greece	−3.088*	−4.229	0.700
Ireland	−5.690*	−2.449	0.200	Ireland	−6.522*	−2.380	1.200
Malta	−4.461*	−2.270	1.800	Malta	−3.366*	−4.021	1.200
Romania	−6.577*	−3.977	0.700	Romania	−4.244*	−2.231	1.100
poland	−5.229*	−2.251	1.200	poland	−6.652*	−2.219	1.000
Slovakia	−5.171*	−3.181	1.600	Slovakia	−6.258*	−2.579	0.700
Sweden	−6.722*	−4.359	1.800	Sweden	−6.871*	−2.870	0.600
Slovenia	−5.090*	−4.249	1.400	Slovenia	−3.722*	−4.861	0700
Estonia	−6.790*	−3.990	1.500	Estonia	−4.868*	−4.321	1.290
Panel (b): Group results							
		Statistics	p-value			Statistics	p-value
Mean		−5.241*	0.000	Mean		−5.677*	0.000
Max		−6.790*	0.000	Max		−7.521*	0.000
Median		−5.229*	0.000	Median		−5.721*	0.000

relationship between GDP and REC is not only good but also negative. Claim that economic growth boosts ECFP first but also improves the climate. NRR grows with economic recovery. We observed that during a time of fast development, the absence of severe limitations stressing eco-friendly considerations had enhanced the ecological impact(Saboori et al., 2017). Because of this, it is necessary to reevaluate present practices to establish limits that will protect the environment while also limiting the damage it does(Rasoulinezhad and Saboori, 2018).

The Hausman test was performed first, and then we used the panel modeling technique. The Hausman test recommended the random-effects model estimate since we could not dismiss the random-effects model's continuity null hypothesis (Yang et al., 2021). Table 4's calculations show that basic and secondary learning levels, financial expansion, and Non-renewable energy Certificates (REC) positively impact elementary energy use. On the other hand, GDP and the internationalization of the economy have a negative impact. The PCSE and FGLS estimates were used to adjust the estimating procedure. According to our empirical estimating procedure, they all yielded comparable findings, showing that it may be used in other methods. Findings may be seen in Tables 4 and 5. Before the final development of the panel model, several tests were performed.

Table 5 shows the CEMG-based long-run effect on carbon footprints in developing SEA countries from factors like non-renewable energy, international trade, natural resource rents, and economic growth. The U-shaped EKC hypothesis between economic development and emissions of carbon dioxide in SEA is supported by results from CS-ARDL. It turns out that rising GDP has a positive effect on CO2 production (CO2). To the 1% threshold of significance, reliability coefficients of 0.522 for GDP are meaningful. This highlights how increased economic expansion in emerging SEA economies increases carbon dioxide emissions and affects the quality of the environment. Moreover, there is a negative and statistically significant relationship between the square root of economic growth and carbon emissions. The outcomes offer corroborating evidence for the EKC U-shaped theory. Reducing carbon dioxide emissions and maintaining a clean environment are hard for developing Southeast Asian countries. Therefore, high intakes of non-renewable energy may raise carbon dioxide emissions to achieve a high economic growth performance in the initial stages(Taghizadeh-Hesary et al., 2021). When their economy reaches a more advanced stage of development, Southeast Asian nations may excel and show off their capacity to rein in carbon dioxide emissions. The findings show that carbon emissions will decrease if the per capita is raised beyond a certain point (a tipping point). The results of this research backed up the findings of (Li et al., 2021) that a strong association between GDP growth and carbon dioxide emissions is typical for developing Southeast Asian countries. Preserving a pristine ecosystem is reliant on responsibly using renewable sources of energy. An increase in non-renewable energy use leads to a decrease in carbon dioxide emissions in SEA countries in the long term, as shown by the REC scaling factor of 0.456, which is significant at the 5% significance level and shows a negative sign. Emissions of carbon dioxide in the SEA area may be reduced by using renewables. With everything else held constant, the results show that a 1% rise in renewables may cut carbon dioxide emissions by around 0.456%. This implies that the sustainability objectives can be met by 2030 (Liu et al., 2017)with the help of new non-renewable energy or an increase in the proportion of renewable power in overall energy consumption.

Table 5
CCEMG long term results.

Univariate models	GDP = f(NNR)	GDP = f(REC)
Denmark	0.413*	0.129
Greece	0.214*	−0.039
Ireland	0.339*	−0.117*
Malta	0.831*	0.369*
Romania	0.949*	−0.129
poland	0.331*	0.069*
Slovakia	−0.011	0.108
Sweden	0.221*	0.013
Slovenia	0.081	0.080*
Estonia	0.687*	−0.061
Panel	0.681*	0.051

The abundance of natural resources in Belgium contributes to the country's ecological footprint. To meet environmental objectives without endangering Germany's economic growth, the nation aims to establish ecological footprint requirements for key sectors of the economy. This is similar to the claim that a rise in resource rent leads to an increase in economic recovery. REC has both a good and a negative impact on ECFP's explanation. Similarly, NRR demonstrates a negative asymmetric long-term connection with GDP. Thus, an increase in economic recovery is likely to aggravate NRR's already-unfavorable situation. Results were the same. Also, the demand for NRR grows due to economic growth, which negatively influences the environment. This shows that NRR is not extracted and utilized efficiently and more effectively.

Consequently, resources and the environment suffer from a lack of NRR, while advances in NRR lead to a reduction in environmental degradation and an enhancement in economic recovery. Green technology, when used properly, may reduce pollution to a large degree. To counteract the negative consequences of climate change, China's government has turned to green technologies (see Table 6). Last but not

Table 6
PFTY causality test and multivariate model.

Null hypotheses	H_0: lnNRR$\nrightarrow$ln GDP				H_0: ln GDP$\nrightarrow$lnNNR			
Countries	Test stat.	p-value	p	k	Test stat.	p-value	p	k
Denmark	3.777	0.339	4	1	1.806	0.739	4	1
Greece	12.39**	0.039	4	2	3.129	0.418	4	2
Ireland	0.419	0.580	1	1	3.681***	0.059	1	1
Malta	0.852	0.718	2	1	2.290	0.311	2	1
Romania	5.888**	0.019	1	1	1.179	0.290	1	1
Poland	7.641**	0.029	1	1	0.590	0.490	1	1
Slovakia	2.029	0.118	1	1	0.811	0.390	1	1
Sweden	12.622**	0.029	3	2	0.721	0.859	3	2
Slovenia	0.031	0.868	1	2	0.450	0.529	1	2
Estonia	3.541**	0.049	1	1	0.731	0.459	1	1
Panel	39.641*	0.003	–	–	18.017	0.519	–	–
Null hypotheses	H_0:lnREC$\nrightarrow$ln GDP				H_0: ln GDP$\nrightarrow$lnREC			
Denmark	Test stat.	p-value	p	k	Test stat.	p-value	p	k
			–	–			–	–
Greece	4.432	0.278	4	1	24.709*	0.000	4	1
Ireland	7.721***	0.068	4	2	7.859	0.139	4	2
Malta	0.068	0.769	1	1	2.307***	0.088	1	1
Romania	2.199	0.218	2	1	0.770	0.543	2	1
Poland	3.807***	0.088	1	1	0.429	0.469	1	1
Slovakia	2.441***	0.059	1	1	1.539	0.229	1	1
Sweden	0.131	0.779	1	1	0.078	0.629	1	1
Slovenia	11.90**	0.011	3	2	3.388	0.478	3	2
Estonia	0.118	0.688	1	2	0.141	0.759	1	2
	0.537	0.500	1	1	0.350	0.590	1	1
Panel	29.688**	0.031			29.388*	0.000		

least, EGDP has both good and bad effects on GDP's explanation.

The data also show the impact of global trade on greenhouse gas production. The CS-ARDL study found a positive and statistically significant correlation between global commerce and carbon emissions. The results indicate that increased global trade might lead to lower levels of carbon emissions in the SER area. Since international trade is a critical component in advancing technology in the area, the link is simple to understand. On the other side, the present research introduced the interaction word to highlight the novel feature of global trade: the assistance for sustainable power. The negative sign of the interaction effect shown in the results demonstrates the potential for international trade and renewables to decrease carbon dioxide emissions. This emphasizes the fact that international trade may be useful in the development of renewable power. Results from the interaction term indicate that international trade is a crucial influence on the growth of renewable power at the regional scale, which is a major challenge for the developing economies of Southeast Asia.

Coal (CR) was shown to have a good thing as a kind of resource rent, which indicates that coal consumption in the region is a major source of carbon dioxide emissions. The results indicate that a 1% rise in flavored soda rent will promote coal consumption, resulting in a 1.23% increase in carbon dioxide emissions. The desire to rent from coal reserves promotes carbon dioxide emissions in Southeast Asian economies, which then generate tar energy production. According to the World Energy Council, about 25% of the country's coal deposits are located in Southeast Asia.(Graham and Harvey, 2001). Coal use by industrialized nations for electricity generation has historically been a major contributor to global environmental damage (Mohsin et al., 2021). Despite the economic benefits, the increased extraction and usage of coal has led to less money being spent on environmental protection. But Southeast Asian nations have long been known for their wealth, thanks to the forestry industry (Iqbal et al., 2021). According to the research findings, a rise in forest rent may be the main cause of irresponsible forest use, which will increase carbon dioxide emissions. These results correspond to those of (Radonjič and Tominc, 2006) and indicate that a 1% rise in rent from natural forests may result in a 0.19% increase in carbon dioxide emissions in the economies of Southeast Asia and the Pacific. The findings also reveal the compounding impact of rents from natural resources on carbon dioxide emissions in the heavily industrialized Southeast Asian area. Assuming a significance level of 1%, the correlation value of 1.732 for total resource rents (TNR) is statically important. In the long term, this indicates that the total rents from environmental assets significantly and favorably affect CO2 emissions. Increasing carbon dioxide production and a decline in ecological purity have been linked to rising total resource rents in SEA economies. When combined with worldwide smog, local smog will have a detrimental impact on all financial systems, particularly when all financial systems share the same planet for commerce, monetary flows, and the cost of living(Cheng et al., 2020). The results of these tests are shown in Fig. 1. According to the Breusch–Pagan–Godfrey tests, our model is free of heteroscedasticity, with a p-value of 59.85. In addition, the Jarque–Bera test demonstrated residual normalcy with a score of 6.325. Naturally, the economically substantial number indicates that our model has been correctly expressed. Because the VIF value ranges from 1.3–to 2.8, less than 5, no multicollinearity exists in the research model.

There is a direct correlation between economic growth and increased demand for power (i.e., total primary energy, renewable, and non-renewable energy consumption). In Romania (Porter, 1980) found that economic expansion increases energy consumption, whereas financial internationalization decreases it. This conclusion is continuous with this research. We also discovered that financial development had a favorable effect on non-renewable energy consumption, in line with (Porter, 1980) research in 30 OECD nations. In contrast, our findings show that economic globalization has less influence on all forms of energy usage in economies than in 28 OECD nations (Caro and Sadr, 2019). found an increase in non-renewable energy demand due to economic internationalization. By using more non-renewable energy easily accessible at low rates, these emerging financial systems are hoping to expand quicker and reduce their manufacturing costs, which will help them increase profits from their economic activities. It is possible that utilizing more dirty power may worsen the atmosphere's health in the name of profit expectations due to cost minimization, which is bad news for emerging nations. High carbon releases into the weather might degrade the value of the normal ecosystem as a direct result of increased financial expansion causing large non-renewable energy usage. In addition, we verify durability using the Granger causal experiment. The findings of the Appendix. It establishes a reciprocal cause association between secondary schooling and non-renewable energy use. In addition, it demonstrates the reciprocal link between oil usage and economic development, non-renewable energy use, and normal gas usage. Furthermore, the entire energy used is connected to natural gas bi-directionally. Industrialization is also unconnected to non-renewable energy usage and non-renewable energy usage.

Last but not least, for simulating the global primary resource, natural gas, and non-renewable energy requirement profiles in Denmark, Romania, Slovenia, and Estonia, we used (Alexander and Kent, 2022) panel static Generalised Method of Moments (GMM). When predicting energy requirement models, the short-run dynamics and cointegration and cross-sectional dependency are dealt with efficiently using the panel GMM approach(Pan, 2019). results in the Supplement reflect the same results as.

6. Conclusions and policy implications

Applying a newly established panel data approach, this research examines how renewable and natural resources usage affects economic development in the top 10 non-renewable energy-consuming nations between 1975 and 2018. When organizational discontinuities are overlooked, causal links may be drastically altered, resulting in a misunderstanding of non-renewable energy policy and natural resources. The issue is solved by utilizing -based procedures in this paper.

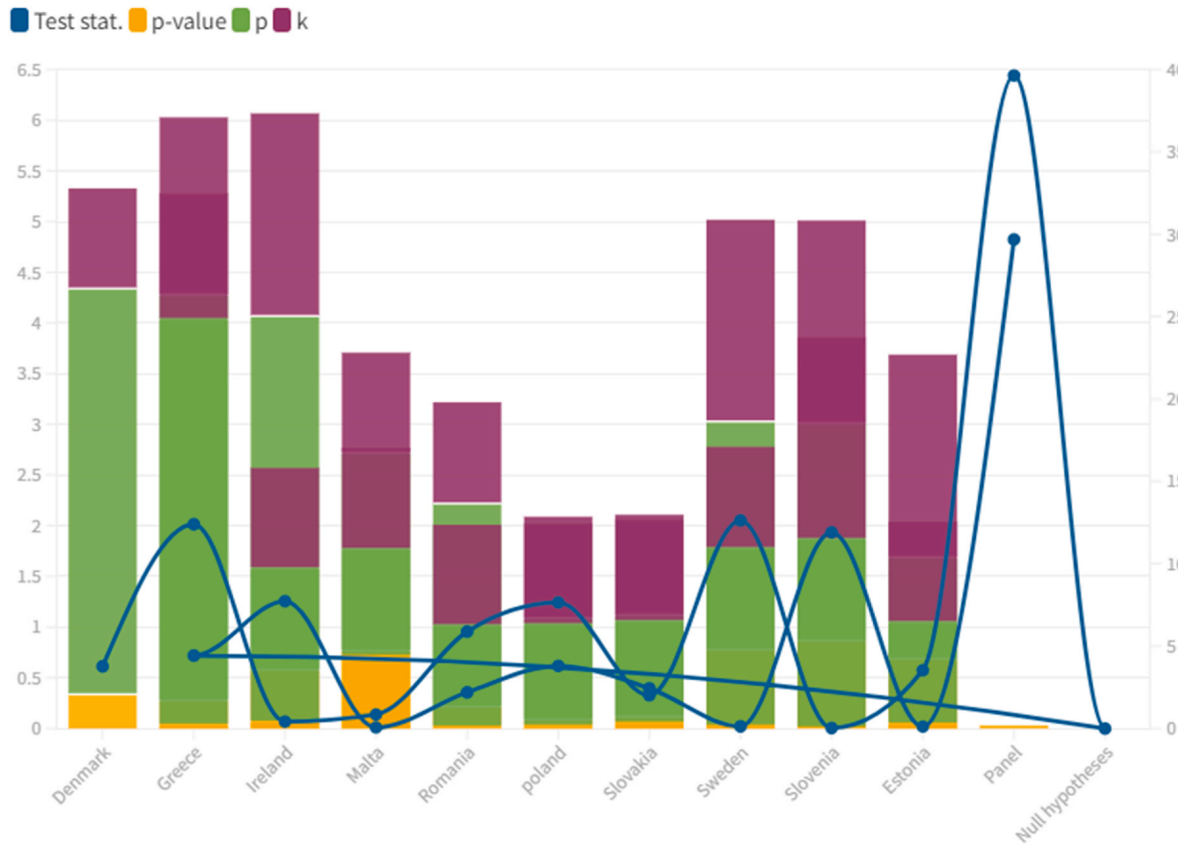

Fig. 1. Causality test for the multivariate model.

Economic recovery in eight of the ten nations studied is supported by natural resources, while non-renewable energy contributes to economic recovery in Denmark, Greece, and Ireland. The causality test results support power growth in Malta, Romania, Greece, and Poland. However, the natural resources-led development hypothesis is true in Slovakia, but the preservation assumption is valid in Ireland and Malta. Overall, the findings demonstrate that non-renewable energy may contribute to economic recovery, although less powerful than non-renewable energy. As a result, governments must keep a careful eye on economic recovery while implementing measures to minimize their use of natural resources and increase their reliance on non-renewable energy sources. Due to the loss of species and exhaustion of natural resources, growing economies must progressively shift from carbon fuels to non-renewable energy (i.e., nature-based energy generated from solar, wind, and water). The long-term environmental quality of the economies might be ensured by increasing the use of pure power in manufacturing and usage.

Some amusing conclusions may be gained by concentrating on the economic recovery pattern across the countries based on two major parts, non-renewable energy and natural resource forms such as fossil fuels, including oil, charcoal, and normal gas—the amount of energy generated from renewable sources. India has made the most progress in non-renewable energy harvesting among the countries. Non-renewable energy intensity has converged over time in Romania, Slovenia, and Denmark. After Romania and Slovenia, Denmark has arrived late to the non-renewable energy game. Despite this, it does not seem to be on an even path.

On the other hand, Estonia has achieved the smallest or most marginal improvement in the use of non-renewable energy. Despite a decline in oil intensity throughout the years, Romania still has the highest level of oil density, followed by Slovenia, Denmark, and. Estonia that countries have the highest coal use density in the world. Coal usage has decreased dramatically in Slovenia, the world's most coal-intensive nation. Estonia's coal intensity has fluctuated the greatest in recent years, although since 2000, it has been steadily decreasing. While Romania's carbon consumption has decreased little over the years, Denmark has reduced its reliance on this principal nitrogen power source and has taken steps to reduce its nitrogen emissions.

Depicts the energy density of normal gas, a less polluting fuel than gas and coal. Romania relied heavily on natural gas in the past. As a consequence, the country has a greater gas intensity as compared to other nations. Nevertheless, only lately has Slovenia's fossil fuel density increased and its charcoal power frequency substantially decreased. On the other hand, Denmark has a changing natural gas intensity pattern. When it peaked from 2001 to 2004, it had already overtaken both Romania and Slovenia. Although Estonia's normal gas intensity is lower than its oil intensity, it is constant in this regard. This material reveals that the two countries have diverged their energy sources to lessen fossil fuel dependency. Despite this, Estonia's primary energy source is still coal, and the country's non-renewable energy intensity shows only little growth in the use of green technologies.

On the other hand, Denmark depends less on charcoal and more on natural resources and non-renewable energy while also lowering its reliance on oil. Compared to the other nations in the group, Denmark should be generating fewer toxins, as shown by this data. Energy density may not be the only way to determine a country's carbon emissions since other variables, such as the use of CO_2-related power sources, also play a role.

6.1. Policy implications

The study's empirical findings support the conclusion that better regulations are needed to regulate the process of extracting or exploiting natural resources. Natural resources, in particular, should be used in a sustainable way that promotes economic development and protects them for future generations, allowing for even greater economic recovery in the long run. Additionally, governments must manage natural resources to prevent excessive exploitation, instead channeling that energy towards promoting industrial and other commercial development to boost the economic region's performance. It is also recommended that policymakers increase spending on non-renewable energy. Non-renewable energy is an environmentally friendly option that supports economic performance and encourages sustainability practices, in contrast to conventional non-renewable energy, which depletes over time and hurts the environment. In addition, this research emphasizes the need to make laws simple and inexpensive for investors to increase gross capital creation. That is to say, enticing investors to expand capital creation, which increases economic activity and boosts economic recovery, is crucial. Finally, this research emphasizes the need to lower political risk. Economies may see an uptick in performance if political stability motivates businesses and investors to spend more on expanding their operations. This has the potential to lower unemployment and poverty while raising per-person incomes.

Ultimately, it can be said that every economy has an urgent need for the process of economic development to be sustainable. But this alone is not sufficient to ensure the preservation of ecological integrity. When it comes to preserving environmental quality while also fostering long-term economic expansion, no one policy can do it alone. The Greenhouse gas emissions reduction methods, which include adopting, deploying, and installing energy-efficient and emission-free technology, should be implemented and pursued by the public governments and authorities of all economies.

Intellectual resources, FDI, trade balance, and Communications technology were not considered in this research because of space constraints and the lack of a comprehensive dataset available for analysis (ICT). These states must make the switch to green manufacturing and the service sector. Future research should investigate the Environmental Kuznets Curve (EKC) Hypotheses to verify the efficacy of this procedure. These assumptions would verify a change to a sustainable route. Such areas may benefit from further investigation in the future, and this study's findings may be expanded upon by examining the correlation between the dependent variable and additional environmental deficit indicators like the frequency and severity of environmental hazards, the greenhouse gases in the atmosphere, and the health effects of this environmental damage.

Declaration of competing interest

The authors declare that they have no known conflict of interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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