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RESEARCH ARTICLE

Green investment, institutional quality, and environmental performance: evidence from G-7 countries using panel NARDL approach

Jiguo Zhao[1] · Saif ur Rahman[2] · Sahar Afshan[3,4] · Muhammad Sibt E. Ali[5] · Hammad Ashfaq[6] · Sadia Idrees[7]

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Abstract

The foremost purpose of the study is to establish a point that an economy of G-7 countries has an abundance of resources to tackle the environmental changes that occur in the world, but these countries are still behind the line because in this modern era, environmental performance changes their shape, dimension, and nature very frequently and create a huge impact on globalization of world economy. To fill this gap, we use green investment, institutional quality, and economic growth on environmental performance for this, we use four proxies for green investment and three proxies for greenhouse gas, and we also use six proxies of institutional quality to do this using period of 1997 to 2021. Moreover, we have used the panel non-linear autoregressive distributed lag method to evaluate the long-run and short-run asymmetric effects of green investment, institutional quality, and economic growth on greenhouse gas emissions. The findings of the study affirm that the positive change of green investment has a positive and significant relationship with environmental performance, while the negative change of green investment has a significant and positive influence with environmental performance in the long run. Furthermore, the outcomes demonstrate that the positive shock of institutional quality has a positive and significant relationship with environmental performance, while the negative shock of intuitional quality has a significant and positive association with environmental performance in the long run, whereas positive change in economic growth has a positive and significant with the environmental performance, while the negative change of economic growth has a positive effect with environmental performance in the long run. This study finds future precautions that institutional quality has to perform exceptionally and shows results very rapidly, while green investment with economic growth has also made a deadly combination to control greenhouse gas emission, so the role of G-7 countries is pretty clear and straight. Furthermore, it is suggested that governments and policymakers take a proactive stance to promote resource acquisition and investment across all industries. To reduce gas emissions, public interest might also be complementary to private ones. So, economic policymakers, specifically in G-7 countries, should consider strategies that support sustainable economic growth.

Keywords Green investment · Institutional quality · GDP growth · Panel NARDL · G-7 countries

Responsible Editor: Arshian Sharif

✉ Saif ur Rahman
saifrao12@gmail.com

Jiguo Zhao
zhangmoxin-8891@163.com

Sahar Afshan
sahar.afshan15@gmail.com

Muhammad Sibt E. Ali
ali4bzu@gmail.com

Hammad Ashfaq
hammad_punjabianz@hotmail.com

Sadia Idrees
midrees485@gmail.com

1 Xinxiang Vocational and Technical College, Xinxiang 453000, China

2 Faculty of Economics & Commerce, Superior University, Lahore, Pakistan

3 Sunway Business School, Sunway University Malaysia, Subang Jaya, Malaysia

4 Adnan Kassar School of Business, Lebanese American University, Beirut, Lebanon

5 School of Business, Zhengzhou University, Zhengzhou, Henan, China

6 Superior University, Lahore, Lahore, Pakistan

7 University Utara Malaysia, 06010 Sintok, Kedah, Malaysia

Introduction

The greatest danger to the global economy for sustainability and success is environmental performance. As long as human development increases with time, it creates a huge burden on the economic system due to environmental crisis (Hammed and Arawomo 2022). During the growth process, human efforts could also lead to environmental performance. The performance can be in the form of air pollution and some other forms that pose a serious threat to human beings. Therefore, any government's primary goal should be to protect the environment. It is commonly accepted that protecting the environment is essential for maintaining human life and promoting national sustainability (Huo et al. 2020; Saarinen et al. 2020; Su et al. 2022). Global temperatures have increased along with population growth to 1.9 °F as of 1880; sea levels have risen 178 mm in the past century; and greenhouse gas (GHG) emissions have increased to 413 parts per million, the highest level in 650,000 years. Challenging climate change may currently be the major environmental and developmental concern (Aswani et al. 2021; Bhat et al. 2022). All countries express concern over green technologies as the world is experiencing greenhouse gases and changes in the climate which in turn impacts the environment as well as the economy. Innovation returns humiliation of the environment without compromising development and growth. Due to the ongoing, growing pollution problem, all world economies have begun focusing on environmental safety tests, and the international community has also taken important action and adopted some vital environmental safety trials to adequate environmental contamination (Doğan et al. 2020). Italy, Canada, USA, Japan, the UK, France, and Germany are among the seven nations that are seen as crucial to the maintenance of a high standard of living in the global economy. Additionally, it improves their productivity and efficient energy production.

Some environmentalist thinks that modern technology could help to minimize GHG emissions as it can improve energy proficiency without disturbing the process of economic development. Environmental technology measures may affect GHG emissions. They influence the pricing of carbon-based fuels by introducing taxes that effectively diminish energy consumption and toxin emissions. Furthermore, these policies provide incentives for companies so that they can develop new technologies. However, it is argued that advancements in technology reduce resources and damage the environment through the reflection effect. Technology in the industrial sector improves production, which uses energy and raw materials but vitiates environmental performance (Greening et al. 2000; Khan et al. 2017; Zhu et al. 2023). The asymmetric between technological advancements and GHG emissions is, however, less clear from empirical evidence. Similar to that, this study adds to the body of knowledge by estimating if innovations can reduce GHG emissions (Amin et al. 2020; Mohsin et al. 2021). The acceptance of green technology thus creates a win–win situation for both economies by representing technology in economic activities and maintaining the performance of the environment through pollution reduction. The sustainable goals of development primarily focus on the change in climate and finding effective solutions to this complex issue. Green technology also offers a balanced approach to addressing global problems and fostering economic growth, which is a crucial prerequisite for achieving sustainable growth (UNCTAD 2018). Various studies (Ahmad et al. 2021; Baloch et al. 2020; Chen et al. 2021; Khan et al. 2021; Malik et al. 2020; Ulucak and Khan 2020) of CO2 emissions were utilized as a stand-in for environmental performance. However, due to a variety of factors, the current study exclusively examines the Group of Seven nations (France, UK, Canada, Italy, Japan, Germany, and the USA). For instance, it is stated that the Group of Seven countries consumed a significant portion of the world's energy in 2019 and owned 30.7% of the global GDP (Khan et al. 2021). Complex economies transition to technical systems that need a high level of knowledge and expertise as a result of changes in production and industrialization. Consumption of renewable energy, ecologically responsible for energy efficiency, and production for different products, for instance, maintain a green economy (Ahmad et al. 2021; Khan et al. 2022; Swart and Brinkmann 2020). The International Energy Agency (IEA) reports that worldwide production and use of renewable energy are increasing (Energy 2019; Jabeen et al. 2021). The international community is paying more attention to green technology breakthroughs as a result of the increased interest in the environment and environmental challenges. Global attention must be paid to developing and implementing green innovation if we are to attain green growth. The most cutting-edge tools for achieving sustainable development in all economies are environmental legislation and green innovation. In order to stop the environmental ruin, many nations have implemented technology patents to limit air, water, and soil pollution.

This study examined the control of institutional quality with environmental performance in Group of Seven countries. Different research has shown various environmental degradation examples. However, still, we lack the best possible solution to overcome the environmental problem. Most of the literature is focused on the process of growth and development, and for this, there are a lot of policies, but institutions ignored the impact of environmental factors that affect the world's economy very badly. Greenhouse gas emissions are a major contributor to global warming, exacerbating general environmental conditions by depleting the ozone layer and affecting public health. The establishment of a socioeconomic legal and cultural structure is tied to the institutional quality and objectives carried out by national institutions. The link between institutional performance and environmental performance is another difficult topic. Political and commercial factors have an impact on institutional performance, and this complex structure moves through several institutional channels (Glicksman et al. 2023; Kang and He 2018; Rahman et al. 2021). The development of targeted environmental and economic policies is thought to be essential for advancing the transition process, but for these policies to be successfully monitored and carried out, they will need to be coupled with strengthened institutions (Dasgupta et al. 2016; Khan et al. 2019a, b; Liao et al. 2017). Olson (1996) also suggested that impartial and effective government institutions might be crucial in fostering constructive cooperation among market actors. As a result, improving institutions' quality becomes crucial to solving environmental issues.

We measured green investment using total patent applications, renewable energy consumption, fixed telephone number subscribers, and R&D activities. Patent applications are thought to be a more accurate proxy for green investment because they reflect an economy's overall technological development, not just in the energy sector. It has taken a lot of work to quantify the relationship between these factors in a single framework throughout the Group of Seven nations. A political forum for intergovernmental discussion is the Group of Seven countries. The greatest advanced economies and liberal democracies in the world are its members. By 2020, the collective group will be responsible for between 32 and 46% of the world's GDP, over 50% of its net worth, and roughly 10% of its populace. Members are major players in international affairs and uphold close political, diplomatic, economic, social, legal, environmental, religious, and cultural ties with one another (Can and Gozgor 2017; Chu 2021; Yilanci and Pata 2020). To achieve this, different countries participate to eliminate the most devastating issue of climate change, and global warming and attaining carbon objectivity target for a greenhouse gas–free society. Nevertheless, enough information is gathered.

The current study emphasizes on the dynamics and primary research areas of green investment, institutional quality, and economic growth on greenhouse gas effects and offers research needs for subsequent research projects. As far as we are aware, the current study is the first to attempt to combine the systematic literature on greenhouse gases, allowing us to address the following research agendas: RQ1: How do GI and IQ affect GHG from G-7 nations? RQ2: How do dependent variables and independent variables interact dynamically? RQ3: How do dependent variables and independent variables respond to long- and short-term asymmetry? And RQ4: Which areas of the published literature need additional study?

During the development process, first of all, environmental performance decreases as a result of the development process, but after passing a certain point, it begins to increase. This inverse U-shaped GDP pollution trend is referred to as the environmental Kuznets curve (EKC) (Grossman and Krueger 1991, 1995; Sarkodie and Strezov 2019). In general, trade openness scale effect and rising energy consumption are to blame for the initial phase of the economic growth's adverse impact on environmental quality. However, the technique and composition effect would result in a favorable influence on the environment at a later stage (Destek and Sarkodie 2019; Mrabet and Alsamara 2017).

When development interacts, environmental quality initially degrades and then, after reaching a certain limit, begins to advance. The EKC is another name for this inverse U-shaped gross domestic product pollution design (Grossman and Krueger 1991, 1995; Sarkodie and Strezov 2019). However, it would significantly affect the climate at a later stage due to the method and organization impact. In general, the negative impact of green investment on environmental quality at the underlying stage of improvement is due to the scale impact of exchange receptiveness and increased energy utilization (Destek and Sarkodie 2019; Mrabet and Alsamara 2017). In terms of scale, the natural quality deteriorates as a result of extra financial activities (transport, modern creation, and deforestation) and energy usage because, in the early stages of improvement, more attention is paid to development than environmental quality. People desire cleaner atmosphere to obtain a better expectation for daily comforts later, when wage level expansions occur in the second transformative phase under strategy impact (Antweiler et al. 2001; Sarkodie 2018; Grossman and Krueger 1991; Mahalik et al. 2018). In this regard, production of goods based on dirty invention is replaced with cleaner innovation or with the administrations sector, notably affecting the climate and known as the "synthesis impact" (Udeagha and Ngepah 2019; Uddin et al. 2017; Antweiler et al. 2001).

To investigate the EKC hypothesis in the G-7 countries, this article assessed the investment-environment nexus using a variety of environmental variables. It uses a cutting-edge method called panel nonlinear autoregressive distributed lag (NARDL). According to our research, all groups of G-7 nations have inverted-U-shaped EKCs when carbon dioxide (CO_2) and nitrous oxide (N_2O) are utilized as environmental indicators. However, the entire G-7 has a U-shaped EKC. The G-7 nations should maintain sustainable biocapacity utilization and continue to implement green investment strategies in all sector changes.

The current study aims to assess how economic growth, institutional quality, and green investments relate to environmental performance and their function in the EKC for G-7 countries. Although many researchers have examined the effects of green investments on economic development and institutional quality on environmental performance in various nations, the G-7 countries have produced very little comprehensive literature on the topic (Ali et al. 2021). Few studies that have assessed green investments, institutional quality, and economic growth in the context of EKC in G-7 countries are currently available. As a result, and in line with the explanation above, this research contributes to the literature in many ways: (i) It is a pioneering study that describes the relationship between environmental performance, institutional quality, and green investments with reference to EKC in G-7 countries; (ii) in contrast to other empirical investigations, the present study makes use of a novel method known as "panel nonlinear autoregressive distributed lag (NARDL)" that can address a number of methodological concerns with panel data, such as heterogeneity and cross-sectional dependency (CSD). (iii) The majority of EKC literature uses only CO2 emissions as a proxy for greenhouse gases, which is an inadequate measure to capture environmental effects. The panel NARDL technique calculates all effects by taking into account heterogeneous slopes and assuming that the variables can be represented by a common factor. When CO2 emissions are employed as the only substitute for greenhouse gases, policymakers run the risk of being misled. Therefore, more comprehensive environmental variables are used to get reliable results. So, by taking into account greenhouse gas emissions of carbon dioxide (CO2) and nitrous oxide (N2O), this study addresses environmental issues in a contemporary context; (iv) it makes insightful recommendations based on the findings, which will pave the way for future research on the relationship between green investment institutional quality and economic growth on environmental performance and its implications in G-7 countries.

In the current literature, there is a lot of discussion about the research on the connection between economic growth and environmental performance. Additionally, governments and institutions started to worry about how economic growth would affect environmental performance even G-7 countries also face similar problems because environmental pollution affects badly economic growth, and in recent times, the huge climate shift changes the dimensions of every economic system. It is considered a crucial tool for promoting economic growth and greenhouse gas emissions because it is a way to improve processes and products when developed countries increase their economic growth process, greenhouse gas emission automatically increases; the important thing is how much government can control it in time. Since the middle of the twentieth century, greenhouse gas (GHG) emissions have been regarded as one of the primary causes of global warming, based on the Fifth Assessment Report of the United Nations Intergovernmental Panel on Climate Change. Avoiding climate change is one of the most significant goals of the twenty-first century because renewable energy is the primary source of GHG emissions and can be reduced or replaced. This idea provides evidence of the risks associated with unsustainable economic expansion. Nevertheless, there is a gap in the research that will be filled by this study, which will be comprehensive in its exploration of the link over the short and long term for G-7 countries utilizing a variety of contemporary empirical methodologies (Fig. 1).

The study aims to estimate the impact of green investments, institutional quality, and GDP growth on environmental performance in a panel of G-7 countries (i.e., France, Germany, Italy, Canada, UK, USA, and Japan) over the 1997–2020 period, taking into consideration the aforementioned influences. In this approach, every effort has been made to predict how global warming and climate change would develop in the future. In any case, no such empirical investigation addressed whether the greenhouse gas independence targets could be achieved. There is still a need for additional research in this field. In response, the goal of this study is to pinpoint the G-7 economies' precise greenhouse gas independence objective. To assist policymakers in developing effective policies for environmental sustainability in these countries, we focused on the asymmetric relationship between green investment, institutional quality, GDP growth, and greenhouse gas emissions in

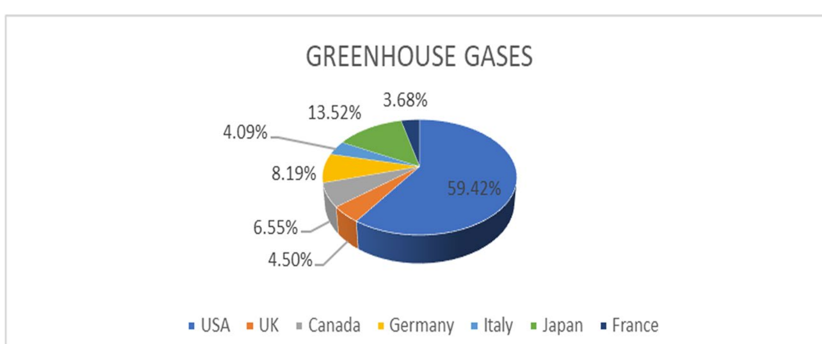

Fig. 1 Share of the G-7 countries in their total greenhouse gases figures

such a high-producing and quickly expanding region in our study. Therefore, the prime goal of the study is to regulate how much green investment regulates greenhouse gas emissions. The study's objectives also include looking into how institutional quality affects greenhouse gas emissions.

Literature review

There are two sub-sections within this section. In this study, we give theoretical literature review and empirical literature review about greenhouse gas emissions, while the latter identifies the research gap from the literature already in existence.

Theoretical literature review

The environmental Kuznets curve states that economic growth initially results in environmental degradation, but that, beyond a certain point, society begins to improve its relationship with the environment, and levels of environmental degradation start to drop. Additionally, it might indicate that environmental preservation is a gain from economic development. There is no guarantee that economic growth will lead to a better environment, say critics, and this is frequently not the case. Economic growth at the very least necessitates a very specific strategy and mindset in order to ensure that it is consistent with a better environment.

The economic policies of rich and emerging nations were significantly influenced by the EKC hypothesis. The EKC hypothesis, according to Webber and Allen, "has key inferences that developing nations should consider for rapid economic growth instead of pursuing pro-environment measures." Because pro-environment regulations only slow down economic growth, economic expansion eventually leads to the achievement of both environmental and economic goals (Webber and Allen 2004). But during the past two decades, several scholars have disputed the EKC theory's underlying premise that environmental costs of economic expansion can be recovered at a later time (Gill et al. 2018), even though the EKC hypothesis is widely used in industrialized nations, there is no consistently positive or statistically significant empirical evidence to support its validity (Karsch 2019). There is no proof that all wealthy countries investing in environmentally friendly and cleaner technologies would eventually lead to environmental progress. Additionally, there is no evidence that wealthy societies everywhere start to seek environmental performance once their basic requirements are covered (Raymond 2004).

Empirical literature review

The essential relationship between green investment and institutional quality with environmental performance has been studied systematically in the literature review. Nowadays, this world is facing an extremely dangerous situation in climate changing and uncertain global warming for these G-7 countries, and the rest of the world makes a lot of effective efforts to come out of this problem and achieve friendly environmental conditions. So, for this (Shen et al. 2021) utilizing panel data of 30 Chinese provinces from the years 1995 to 2017, with an emphasis on financial development, green investment, natural resource rent, and energy consumption with carbon emissions to achieve sustainable development and ensure a clean and clear environment. This research used the methodology of novel cross-sectional augmented autoregressive distributed lags (CS-ARDL) after the study finds long- and short-run impact of the variables on carbon emission, but the study shows that green investment has negative relation with CO_2, whereas national resources have a positive relationship with that. This study needs to establish impactful national natural tax laws and promotion of green investment to control carbon emissions. Another study (Khan 2019) for ASEAN economies examined the interconnection between environmental and economic factors with logistic operations shows that economies' downfall caused because of environmental degradation by taking data from the periods 2007–2017 and using the methods of GMM, and the study finds that poverty and logistic operations are the main cause of environmental degradation. Moreover, this study recommended that there is a need for a strong economic sustainability approach to overcome poverty and improve renewable energy consumption.

Another side (Chien et al. 2021), this study examines how the BRICS nations' carbon dioxide emissions are affected by information and communication technology, economic expansion, and financial development. This study uses quantile regression from the methods of moments to achieve this. The overall findings show that while information and communication technology considerably reduce the level of carbon dioxide emissions only at lower emissions quantiles, economic expansion and financial development contribute to carbon dioxide emissions across all quantiles (Anwar et al. 2022). In 15 Asian economies between 1990 and 2014, this study intends to investigate the effects of urbanization, renewable energy consumption, financial development, agriculture, and economic growth on CO_2 emissions. According to empirical data, economic expansion, urbanization, and the use of renewable energy all result in an increase in CO_2 emissions, but agriculture has a negligible effect. Moreover, in this study, the effects of EPU, IQ, and RENE on GGDP for the seven developing nations (E-7) from 1996 to 2019 are examined. We use panel quantile regression (PQR) to do this. The empirical results show that, in E-7 countries, IQ and

RENE increase GGDP, but EPU has a negative impact on it (Jiang et al. 2023).

Furthermore, (Rehman Khan and Yu 2021) give attention to internal environmental management, green supply chain management, and green information systems using the methodology of PLS-SEM modeling for this 415 manufacturing firm's data collected for the hypothesis. The study finds that promotions of GSCPs are needed on a large scale for the betterment of environmental sustainability. Another study (Nathaniel and Khan 2020) shows the impact of energy consumption, economic growth, and urbanization is more considerable in environmental quality with an indicator (ecological footprint) from the period 1990 to 2016 using (STIRPAT) model and this paper recommended that the area is developing without regard for its environment and engaging in trade that produces a lot of emissions. In recent times, CO2 emissions, economic expansion, and energy use have drawn more attention, and the period 1990 to 2016 and the adoption methodology (FMOLS) and (DOLS) and study find that due to an increase in energy consumption, environmental pollution will automatically increase, but it depends on country's policies, so there is a need to implement environmental tax and highlight public rights and removed the offensive subsidies that will help the economy on track.

Dauda et al. (2019) adopt a complete approach and want to identify whether, can innovation reduce the emission of CO2? For this, 18 developed and under-developing countries over time the period of 1990 to 2016, and use a panel (DOLS) to find out the long-run relationship. Furthermore, the finding shows that due to an increase in energy consumption, CO2 increases everywhere, but economic growth reduces CO2 emission in BRICS but increases in G6 countries; therefore, it is recommended that economic growth increase CO2, but it needs to reduce environmental pollution, and government should take serious step to adopt renewable energy like solar energy, wind energy, and hydroelectric power because of all these resource environmental pollution and convert it into a green economy. In another study, (Mensah et al. 2019) with an increase in emissions worldwide, the role of technology increases as well in to fight against emissions for this, and the character of patent, trademark, and economic progress in urbanization is very significant followed by the period of 1990 to 2015 and using the methodology of ARDL approach and take the result from Westerlund panel co-integration test, panel unit root test, cross-sectional dependence test, and Granger causality test, so it is recommended that automobile industries should come forward make some effort to reduce the environmental pollution and government all should take encourage everyone and make effective policies. In the same year, another researcher (Fethi and Rahuma 2019) use an advanced form of environmental Kuznets curve to examine the main cause of carbon dioxide emission and the part of eco-innovation that can reduce this CO2 using the methodology of DSUR co-integrating test, CADF and the CIPS unit root tests, and DH panel causality test using the 2007–2016 timeframe. It is found that with the increase in real income, research and development increase as well, and it can reduce energy consumption. For this, it is suggested that huge funds are needed to control environmental pollution with effective and speedy research and development sectors.

Researchers want to use the VECM approach and the time period of 1971 to 2015 to investigate the underlying relationship between technical advancement and CO2 emissions with economic growth, power consumption, and energy price in Malaysia (Yii and Geetha 2017). In the short run, this study reveals a negative relationship between CO2 emissions and technological innovation, but it finds no such relationship in the long run.

Methodology

Cross-sectional dependence tests

It is a common practice to assess the CSD in panel data using the Lagrange Multiplier (LM) test. Breusch and Pagan (1980) devised this test in its original form. The LM test of Breusch and Pagan (1980) has the following standard form:

$$\mathrm{LM}_{\mathrm{BP}} = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{p}_{ij}^{2}, \tag{1}$$

where $\hat{p}_{ij}^{2}$ presents a sample estimate for the pairwise correlation coefficients. The Breusch and Pagan (1980) LM test is appropriate when T and N are sufficiently large. If the average pairwise correlation is near to 0, this test is no longer suitable (Pesaran 2004).

Consequently, in order to address the deficiencies in the LM_{BP} test, using the scaled version of the LM test as a base, Pesaran (2004) produced another test statistic. Even with large N and little T, this test can be used:

$$\text{Scaled LM test} = \sqrt{\left(\frac{N}{N(N-1)}\right)}\left[\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \left(T\rho_{ij}^{2} - 1\right)\right] \tag{2}$$

With large N and very small T, this test is likely to show significant size deviations. Pesaran (2004) suggested a different cross-sectional dependence test that can be used with large N and small T to get around this problem:

$$\text{CD test} = \sqrt{\left(\frac{2T}{N(N-1)}\right)}\left[\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \rho_{ij}\right] \tag{3}$$

With $T \to \infty$ and $N \to \infty$, under the null hypothesis, the CD test has an asymptotic standard normal distribution. Instead of using their squares as in the LM test, this test is based on a scaled average of the pairwise correlation coefficients. In the presence of heterogeneous dynamic models and many breaks in the slope coefficients, this test provides reliable results.

In order to improve the LM test, Baltagi et al. (2012) used the exact mean and variance of the LM statistics, which are expressed as follows:

$$\mathrm{LM}_{\mathrm{adj}} = \sqrt{\left(\frac{2T}{N(N-1)}\right)}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\rho_{ij}\frac{(T-k)\rho_{ij}^2-\mu_{Tij}}{\sqrt{v_{Tij}^2}} \quad (4)$$

where μ_{Tij} and v_{Tij}^2 are the strict mean and variance of $(T-k)\rho_{ij}^2$ arranged by Baltagi et al. (2012).

Panel unit root test

Compared to first-generation unit root tests, the CIPS panel unit root test is a second-generation unit root test. Many investigations, including Levin et al. (2002), Im et al. (2003), and Maddala and Wu (1999), used first-generation unit root tests that primarily assumed cross-sectional independence and homogeneity. The first generation tests are likely to yield ineffective results if the studied variables are not cross-sectional independent and homogeneous. On the other hand, because it can successfully adjust for CSD and heterogeneity, the 2nd-generation panel unit root test (CIPS-test) created by Choi (2006) and Pesaran (2007) provides results that are more certain.

Model specification

In this study, panel data covering the years 1997 to 2020 are used to experimentally assess the asymmetric relationship between green investment, institutional quality, and GDP growth on greenhouse gas emissions. But we have taken into account Group of Seven countries. Japan, Italy, USA, Canada, France, Germany, and UK are among these countries. Kilo tons of CO2 equivalent are used in this study to measure greenhouse gas emissions. The utilization of green investments is measured with indicators of R&D, application of patents, renewable energy, and fixed telephone subscribers. However, institutional quality provides direction for policy implications to give strength to the economy. World Development Indicators provide data on dependent and independent variables (WDI) except institutional quality data. A linear econometric model is used to investigate how independent variables affect a dependent variable. The model specification is as follows:

$$\mathrm{GHG}_{\mathrm{it}} = \beta_0 + \beta_1\mathrm{GDP}_{\mathrm{it}} + \beta_2\mathrm{GI}_{\mathrm{it}} + \beta_3\mathrm{IQ}_{\mathrm{it}} + \mu_{\mathrm{it}} \quad (5)$$

where *I* denotes country and *t* represents time, whereas GHG is greenhouse gas emissions, GDP is GDP growth rate, GI is for green investment, and IQ is for institutional quality, however, to check the hypothesis of the environmental Kuznets curve.

NARDL approach

The nonlinear autoregressive distributed lag (NARDL) model created by Shin et al. (2014) is described in this section. Applying nonlinear ARDL approach, the study investigates the asymmetric effect of green investment, GDP, and institutional performance on greenhouse gas emissions. The following is the goal of this assessment strategy:

- It enables the co-integration and nonlinear asymmetry to be combined in a single equation. The NARDL model investigates the effects of the deconstructed variables' positive and negative variations on the dependent variable.
- If the sample size is tiny, the model still holds.
- It is adaptable since it does not need the integration of the variables in the same sequence.
- Despite the short sample size, it offers strong empirical results because it is in essence a dynamic error correction representation.

Equation (6) shows change in logarithmic and positive and negative changes too in descriptive variables will be written as follows:

$$\begin{aligned}\mathrm{lnGHG}_{\mathrm{it}} &= \propto_{\mathrm{it}} + \delta_{\mathrm{it}} + \beta^{+}\mathrm{lnGI}_{\mathrm{it}}^{+} + \beta^{-}\mathrm{lnGI}_{\mathrm{it}}^{-} + \beta^{+}\mathrm{lnIQ}_{\mathrm{it}}^{+} \\ &\quad + \beta^{-}\mathrm{lnIQ}_{\mathrm{it}}^{-} + \beta^{+}\mathrm{lnGDP}_{\mathrm{it}}^{+} + \beta^{-}\mathrm{lnGDP}_{\mathrm{it}}^{-} + u_{\mathrm{it}}\end{aligned} \quad (6)$$

in which ∝ is the intercept, β are the coefficients of the variables, μ_{it} is the error, and *t* is for time, *i* represents countries, ln is the natural logarithm, and δ are trending effects.

The nonlinear autoregressive distributed lag (NARDL) framework of Eq. (7) can be written as follows:

$$\begin{aligned}\Delta lnGHG_{it} &= \mu + \rho lnGHG_{it-1} + \vartheta^{+} lnGI_{it-1}^{+} + \vartheta^{-} lnGI_{it-1}^{-} \\ &\quad + \varnothing^{+} lnIQ_{it-1}^{+} + \varnothing^{-} lnIQ_{it-1}^{-} + \omega^{+} lnGDP_{it-1}^{+} \\ &\quad + \omega^{-} lnGDP_{it-1}^{-} + \sum_{j=1}^{n-1} \alpha j \Delta lnGHG_{it-j} \\ &\quad + \sum_{j=0}^{n2}(\overset{+}{\pi^{j}} \Delta lnGI_{it-j}^{+} + \pi_j^{-} \Delta lnGI_{it-j}^{-}) \sum_{j=0}^{n3}(\overset{+}{\tau^{j}} \Delta lnIQ_{it-j}^{+} \\ &\quad + \tau_j^{-} \Delta lnIQ_{it-j}^{-}) + \sum_{j=0}^{n4}(\sigma^{+} lnGDP_{it-1}^{+} + \sigma^{-} lnGDP_{it-1}^{-}) + \epsilon_{it}\end{aligned} \quad (7)$$

Using the following equation, the short-run NARDL elasticities with an error correcting mechanism can be calculated:

$$\begin{aligned}\Delta lnGHG &= \mu + \sum_{j=1}^{n-1} \alpha j \Delta lnGHG_{it-j} + \sum_{j=0}^{n2}(\overset{+}{\pi^{j}} \Delta lnGI_{it-j}^{+} \\ &\quad + \pi_j^{-} \Delta lnGI_{it-j}^{-}) \sum_{j=0}^{n3}(\overset{+}{\tau^{j}} \Delta lnIQ_{it-j}^{+} + \tau_j^{-} \Delta lnIQ_{it-j}^{-}) \\ &\quad + \sum_{j=0}^{n4}(\forall^{+} lnGDP_{it-1}^{+} + \forall^{-} lnGDP_{it-1}^{-}) + \varnothing ECM_{it-1} + \epsilon_{it}\end{aligned} \quad (8)$$

The effects of the variables IG, IQ, and GDP can be divided into positive and negative components, as we have demonstrated in Eq. (6).

$$\mathrm{lnGI_{it}} = \mathrm{lnGI_0} + \mathrm{lnGI^+_{it}} + \mathrm{lnGI^-_{it}} \quad (9)$$

$$\mathrm{lnIQ_{it}} = \mathrm{lnIQ_0} + \mathrm{lnIQ^+_{it}} + \mathrm{lnIQ^-_{it}} \quad (10)$$

$$\mathrm{lnGDP_{it}} = \mathrm{lnGDP_0} + \mathrm{lnGDP^+_{it}} + \mathrm{lnGDP^-_{it}} \quad (11)$$

In all three Eqs. (9, 10, 11) in which $\mathrm{lnGI_0}$, $\mathrm{lnIQ_0}$, and $\mathrm{lnGDP_0}$ show the random initial value and then $\mathrm{lnGI^+_{it}} + \mathrm{lnGI^-_{it}}$, $\mathrm{lnIQ^+_{it}} + \mathrm{lnIQ^-_{it}}$, and $\mathrm{lnGDP^+_{it}} + \mathrm{lnGDP^-_{it}}$ represent partial sum methods which gather the changes like positive and negative that occurs, respectively, that all are explained as follows:

$$lnGI^+_{it} = \sum_{j=1}^{it} \Delta lnGI^+_{it} = \sum_{j=1}^{it} max\left(\Delta lnGI_j, 0\right), \quad lnGI^-_{it} = \sum_{j=1}^{it} mini\left(\Delta lnGI_j, 0\right) + \epsilon_{it} \quad (12)$$

$$lnIQ^+_{it} = \sum_{j=1}^{it} \Delta lnIQ^+_{it} = \sum_{j=1}^{it} max\left(\Delta lnIQ_j, 0\right), \quad lnIQ^-_{it} = \sum_{j=1}^{it} mini\left(\Delta lnIQ_j, 0\right) + \epsilon_{it} \quad (13)$$

$$lnGDP^+_{it} = \sum_{j=1}^{it} \Delta lnGDP^+_{it} = \sum_{j=1}^{it} max\left(\Delta lnGDP_j, 0\right), \quad lnGDP^-_{it} = \sum_{j=1}^{it} mini\left(\Delta lnGDP_j, 0\right) + \epsilon_{it} \quad (14)$$

The common Wald test is used to look at the long-run symmetry ($\theta + = \theta -$) and asymmetry ($\theta + \neq \theta -$), the implications of the asymmetric cumulative dynamic multipliers on $lnGHG$ of a unit change in$ln\ GI^+_{it}, lnGI^-_{it}, lnIQ^+_{it}, lnIQ^-_{it}, lnGDP^+_{it}, lnGDP^-_{it}$:

$$m^+_h = \sum_{j=0}^{h} \frac{\delta lnGHG_{it+j}}{\delta lnGI^+_{it-1}}, m^-_h = \sum_{j=0}^{h} \frac{\delta lnGHG_{it+j}}{\delta lnGI^-_{it-1}}, \quad m^+_h = \sum_{j=0}^{h} \frac{\delta lnGHG_{it+j}}{\delta lnIQ^+_{it-1}}, m^-_h = \sum_{j=0}^{h} \frac{\delta lnGHG_{it+j}}{\delta lnIQ^-_{it-1}}, \quad m^+_h = \sum_{j=0}^{h} \frac{\delta lnGHG_{it+j}}{\delta lnGDP^+_{it-1}}, m^-_h = \sum_{j=0}^{h} \frac{\delta lnGHG_{it+j}}{\delta lnGDP^-_{it-1}}, \quad m^+_h = 0, 1, 2 \ldots \quad (15)$$

Principal component analysis

We have followed the studies of Li et al. (2022), Law et al. (2014), and Ali et al. (2020) to build PCA. This particular study takes annual data on CO_2 emissions, NO_2, and methane emission (three proxies of greenhouse gas emissions); then, we make PCA (principal component analysis) all proxies of greenhouse gas emissions.

In PCA, the *j*th feature indices are stated as follows:

$$\mathrm{GHG_j} = M_{\mathrm{j1}} N_1 + M_{\mathrm{j2}} N_2 \quad (16)$$

Here, $\mathrm{GHG_j}$ denotes the greenhouse gas. The respective weights of the parameters are denoted by *M*j and *N*j, respectively. M_1, M_2, and M_5 indicate the values of greenhouse gas (methane emissions, NO_2, and CO_2).

Furthermore, we also take Government Effectiveness, Political Stability, Violence, Control of Corruption, Rule of Law, Voice, and Accountability (six proxies of institutional performance) and make PCA for this data and declared it with the name institutional performance (IQ) by developed the study.

We constructed equation for institutional performance (IQ) index using the PCA approach as follows:

$$\mathrm{IQ_j} = O_{\mathrm{j1}} P_1 + O_{\mathrm{j2}} P_2 \quad (17)$$

Here, $\mathrm{IQ_j}$ represents the institutional performance index. The respective weights of the parameters are denoted by $O_{\mathrm{j1}}$and P_{1j}, respectively. $\mathrm{P_1}$, $\mathrm{P_2}$, …, $\mathrm{P_6}$ indicate the values of institutional performance indicators.

Moreover, the green investment measuring renewable energy consumption (% of total final energy consumption), fixed telephone subscriptions (per 100 people), patent applications (residents), and research and development expenditure (% of GDP) all four are proxies of green investment; then, we make PCA (principal component analysis) again as well for green investment.

We generated equation for GI index using the PCA approach as follows:

$$\mathrm{GI_j} = R_{\mathrm{j3}} S_3 + R_{\mathrm{j3}} S_3 \quad (18)$$

Here, $\mathrm{GI_j}$ represents the green investment index. $\mathrm{R_1}$, $\mathrm{R_2}$, and $\mathrm{R_4}$ show values of green investment indicators (renewable energy consumption, fixed telephone subscription, patent applications (residents), research and development expenditure).

Results and discussions

This study aimed to both conceptually and practically investigate the connection between GI, EG, IQ, and EP. The dataset of the G-7 economies was analyzed using a variety of econometric techniques. We used NARDL to evaluate both long- and short-term relationships in addition to CD tests, panel unit root tests, and various co-integration tests.

Table 1 holds descriptive statistics of all variables in complete illustration for G-7 countries. The average greenhouse

Table 1 Descriptive statistics

Descriptive analysis				
	Greenhouse gas	Green investment	Institutional quality	GDP growth
Mean	−1.61	−1.25	−0.01	1.31
Median	0.09	0.11	−0.24	1.76
Maximum	2.10	2.14	2.67	6.86
Minimum	−2.23	−1.94	−3.08	−9.27
Std. dev	0.98	0.97	0.98	2.49
Skewness	−0.06	−0.11	0.16	−1.78
Kurtosis	2.00	1.94	3.01	7.42
Jarque–Bera	6.808	7.36	0.70	225.170
Probability	0.033	0.02	0.70	0.000
Sum	−2.60	−1.90	−2.83	218.98
Sum Sq. dev	154.00	145.00	141.02	1033.67
Observations	161	152	147	167

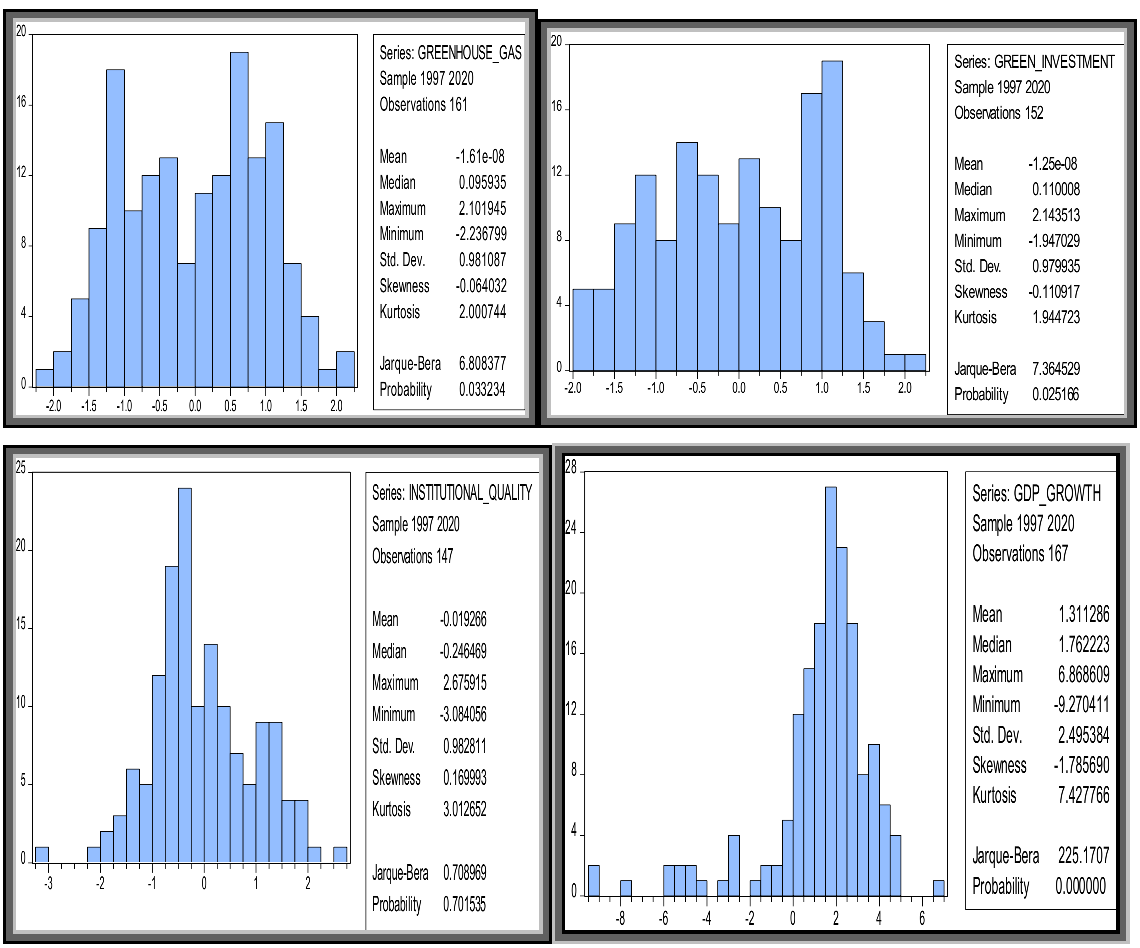

Fig. 2 Green investment, greenhouse omission, institutional quality, and GDP growth trend

Table 2 Cross-sectional dependence test

Variables	CD test		Scaled LM test		Bias-corrected scaled LM	
	Statistic	Probability	Statistic	Probability	Statistic	Probability
EP	30.43	0.00	123.53	0.00	127.34	0.00
GI	27.31	0.00	131.34	0.00	129.65	0.00
IQ	79.21	0.00	222.42	0.00	221.12	0.00
EG	67.65	0.00	103.21	0.00	102.54	0.00

Table 3 The unit root of individual variables

Variables	CIPS	
	At level	First difference
EP	−1.756	−6.132
GI	2.452	2.124
IQ	−1.316	−2.412
EG	−1.984	−5.522

gas emissions of the sample are −1.61, green investment is −1.25, institutional quality is −0.01, and GDP growth is 1.31. An important element in this table is the Jarque–Bera Probability test in which greenhouse gas emission and green investment show 0.033 and 0.02 (which is 3.3% and 2% means its results are significant in both cases), while in institutional quality, its results are insignificant and in GDP growth rate, it shows highly significance (Fig. 2).

As shown in Table 2, the CD test (Pesaran 2004), scaled LM test (Pesaran 2004), and biased-corrected scaled LM test (Baltagi et al. 2012) are all used to test the occurrence of CSD. The results of testing are vital in determining the use of second-generation panel unit root tests, which are more suited in the case of CSD, as well as in determining the proper technique.

Table 3 displays the second-generation unit root test, commonly known as the CIPS test (Pesaran 2007). The CSD is one of the variables in this exam. At the level and first difference, all of the variables are stationary, but none of them is at the second difference. According to the results of the CIPS unit root test, GI, IQ, and EG are stationary at their levels, whereas EP is stationary at the first difference.

NARDL long-run and short-run valuations

In Table 4, the outcomes of the panel NARDL model's long-run and short-run estimations are shown. Assuring the non-linear asymmetric relationship between green investment, institutional quality, and GDP growth on greenhouse gas emissions is the study's main goal. The long-term model's findings show the calculated coefficients of the positive and negative sums for the augmentation and diminution of deconstructed variables. The co-integration test of the

Table 4 Long-run and short-run estimations of the NARDL model

Greenhouse gas emissions are the dependent variable			
Variables	Coefficient	Standard error	*t*-statistics
Long-run estimation			
Green investment (positive)	2.131	0.987	2.157
Green investment (negative)	−1.306	0.623	−2.182
Institutional quality (positive)	−2.578	1.171	−2.201
Institutional quality (negative)	0.758	0.364	2.080
GDP growth (positive)	2.249	1.113	2.020
GDP growth (negative)	1.830	0.912	2.006
Short-run estimation			
COINTEQ 01	−0.057	0.021	−2.701
d(greenhouse gas) (−1)	−0.192	0.090	−2.137
d(green investment) (positive)	4.079	2.01	2.029
d(green investment) (negative)	−1.196	0.600	−1.994
d(institutional quality) (positive)	0.004	0.002	2.285
d(institutional quality) (negative)	0.063	0.031	2.03
d(GDP growth) (positive)	0.003	0.001	2.83
d(GDP growth) (negative)	−0.029	0.012	−2.422
C	−0.239	0.114	−2.096

decomposed variables and greenhouse gas emissions has confirmed the long-run imbalance between them. According to the long-run panel NARDL results, green investment coefficient estimates with positive and negative shocks are 2.15 and − 2.09, respectively. These results are aligning with studies (Dauda et al. 2019; Li et al. 2022; Khan et al. 2017).

In short run, the findings show that greenhouse gas emissions have a negative relationship with institutional quality, GDP growth, and green investment and it indicates that if one-unit increase in dependent variable (greenhouse gas emissions) that decrease independent variables (institutional quality, GDP growth, and green investment) with 2.137, so it is found that in short-run analysis, we strongly need clear and comprehensive policy to reduce the environmental performance and improve green investment institutional quality with GDP growth. Furthermore, short-run institutional quality shows positive shocks like whenever greenhouse gas emission increases institutional quality also increases and vice versa. The positive impact of institutional quality on greenhouse gas emissions suggests that the difficulty to control on all factors affects activities of environmental quality in G-7 countries.

With all factors that affect environmental performance in short run, green investment can dominate in positive shocks because if one-unit increase in institutional quality that increase greenhouse gas with 2.029, but if green investment has negative shocks, then it can become a problem to control environmental performance like if one-unit increase in green investment, it can decrease greenhouse gas with 1.94. So empirical findings suggest that government should take rational decisions and control all the elements in short run, otherwise, it is difficult to give correct estimation for calculations, and after that it become obstacles in long run.

The estimations for both green investment (GI) rises and GI decreases are both positive and negative, according to the long-run findings. The results show that a one-unit rise in green investment (GI-POS) also results in a 2.157 increase in greenhouse gas emissions, while a one-unit decline in green investment (GI-NEG) causes 2.182 increase greenhouse gas emissions. We also find that changes in green investments that are for the better (GI-POS) have a bigger impact on greenhouse gas emissions than changes that are for the worse (GI NEG).

The asymmetric association between institutional quality and environmental performance is further supported by our findings in the long run. The results show that a one-unit rise in institutional quality (IQ POS) results in a 2.201 decrease in greenhouse gas emissions, whereas a one-unit decline in institutional quality (IQ NEG) results in a 2.080 decrease. Comparing IQ POS and IQ NEG, we discover that IQ POS has a greater impact on environmental performance. The research is linked to the findings of Bernauer and Koubi (2009), Ibrahim and Law (2016), and Mehmood et al. (2021), who discovered that institutional quality has a negative impact on greenhouse gas emissions, which eventually enhances environmental performance. In every one of the aforementioned research, the significance of institutional quality in enhancing environmental performance has been emphasized.

Similar findings are made for GDP growth and environmental performance, where we discover an unbalanced link between the two. It is established that a one-unit increase in GDP growth (GDP POS) causes a positive change in greenhouse gas emissions of 2.020, whereas a one-unit decrease in GDP growth causes a reduction in greenhouse gas emissions of 2.006. Positive GDP growth shocks have a greater impact on environmental performance than negative shocks. The relationship between GDP growth and environmental performance, however, suggests that positive change in GDP growth has a greater impact on environmental performance than negative change in economic growth. This is supported by a number of studies, including Aye and Edoja (2017) and Liobikienė and Butkus (2019).

On the subject of greenhouse gas emissions, it is noted that there is an interrelationship between green investment, institutional quality, and GDP development. In order to control all these potential economic roadblocks, we use institutional quality as one of the independent variables. The results show that increasing GDP growth and green investment would reduce greenhouse gas emissions, while decreasing GDP growth and green investment would increase greenhouse gas emissions. Greenhouse gas emissions are positively and significantly with green investments, institutional quality, and GDP growth with positive shocks, while in negative shocks, greenhouse emissions are not significant in showing results. Furthermore, the pollution heaven theory is supported by the correlation between GDP growth and greenhouse gas emissions. The findings imply that to reduce greenhouse gas emissions in the G-7 countries. Green investment is one of the main global greenhouse gas eliminators. This study also finds future precaution that institutional quality had to perform exceptionally and shows result very rapidly, while green investment with GDP growth has also made a deadly combination to control greenhouse gas emission, so the role of G-7 countries is pretty clear and straight because if these countries are failed to control greenhouse gas emission then half of the world getting into the trouble.

Panel co-integration analysis

Tables 5 and pular panel co-integration tests, namely the Pedroni (Pedroni 1999) co-integration test, Kao (1999), and Fisher co-integration tests to determine whether the dependent and independent variables have a long-term relationship. In all cases, we use individual intercept,

Table 5 Pedroni (Engle-Granger based) test: within-dimension

Alternative hypothesis: common AR Coefs			(Panel A: within-dimension)			
Panel co-integration test	Individual intercept		Individual intercept and trend		No intercept or trend	
	Statistics	Statistic weighted	Statistic	Statistic weighted	Statistic	Statistic weighted
Panel v-statistic	−0.251*	−0.663	−0.265*	0.980	0.520*	−0.481
Panel rho-statistic	1.956*	2.093	2.013*	1.645	1.269*	1.569
Panel PP-statistic	2.618*	2.695	2.245*	1.483	1.730*	2.128
Panel ADF-statistics	3.096*	3.460	3.278*	3.809	1.894*	2.602

Basis: Calculation by authors. The lag length was selected by the Schwarz Info criterion

*Specifies the statistically significant at 1% levels

Table 6 Pedroni (Engle-Granger based) test: between-dimension

Alternative hypothesis: individual AR coefs		(Panel B: between-dimension)	
Panel co-integration test	Individual intercept	Individual intercept and trend	No intercept or trend
	Statistics	Statistic	Statistic
Panel rho-statistic	2.480	2.449	2.557
Panel PP-statistic	2.827	1.449	2.996
Panel ADF-statistics	4.441	4.456	3.645

Basis: Calculation by authors. The lag length was selected by the Schwarz Info criterion

Table 7 Kao (Engle-Granger-based) test

ADF (prob.)	Residual variance	HAC variance
0.077*	0.165	0.234

Source: Calculation by authors. The lag length was selected by Modified Hannan-Quinn

*specifies the statistically significant at a 10% level

Table 8 Fisher (combined Johansen) test

Hypothesized no. of CE(s)	Fisher stat. (from Trace test) (prob.)	Fisher stat. (from Max-Eigen test) (prob.)
None	0.000*	0.000*
At most 1	0.000*	0.000*
At most 2	0.006*	0.011*
At most 3	0.522	0.522

Source: Calculation by authors. Probabilities are computed using asymptotic Chi-square distribution

*Specifies the statistically significant at 10% levels

individual intercept with trends, and individual intercept with no trends or intercept followed by statistics test and weighted statistics test, and we also take Schwarz Info criterion as lag length. The analysis of the Pedroni panel co-integration test reports two-dimension test statistics, i.e., within the dimension and between dimension test statistics. The H_0 and H_1 of panel co-integration were compared. According to the results of Pedroni panel co-integration tests, the H_0 of no co-integration can be rejected at a level of significance of 10%, 5%, or 1%. According to Table 4's predicted output, there is a long-term correlation between GDP growth in the Group of Seven nations, institutional quality, green investment, and greenhouse gas emissions.

The augmented Dickey-Fuller (ADF) probability-based Kao panel co-integration test, which was also run, is shown in Table 7 and yields a significant result of 0.077, followed by residual variance and HAC variance. The results of co-integration analysis are thought to indicate that all potential variables have a long-term relationship. The results of the Kao panel co-integration tests point to the possibility of rejecting the null hypothesis of no co-integration at the 10%, 5%, or 1% level of significance. According to Tables 5 and 6 predicted output, there is a long-term correlation between GDP growth in G-7 nations, green investment, greenhouse gas emissions, and institutional quality (Table 7).

An alternate test for co-integration analysis based on Trace and Max-Eigen tests is the Fisher panel co-integration test, which is run in Table 8. The results of all co-integration tests are shown in Table 7, where the estimated output of the study implies that there is a long-term relationship between all conceivable variables. Based on the findings of Fisher panel co-integration tests, it is possible to reject the null hypothesis of no co-integration with a level of significance of 10%, 5%, or 1%. According to Table 7's anticipated output, there is a long-term association between GDP growth in G-7 nations, institutional quality, green investment, and greenhouse gas emissions (Fig. 3).

The study also used stability tools to examine the models' structural stability. According to Brown et al. (1975),

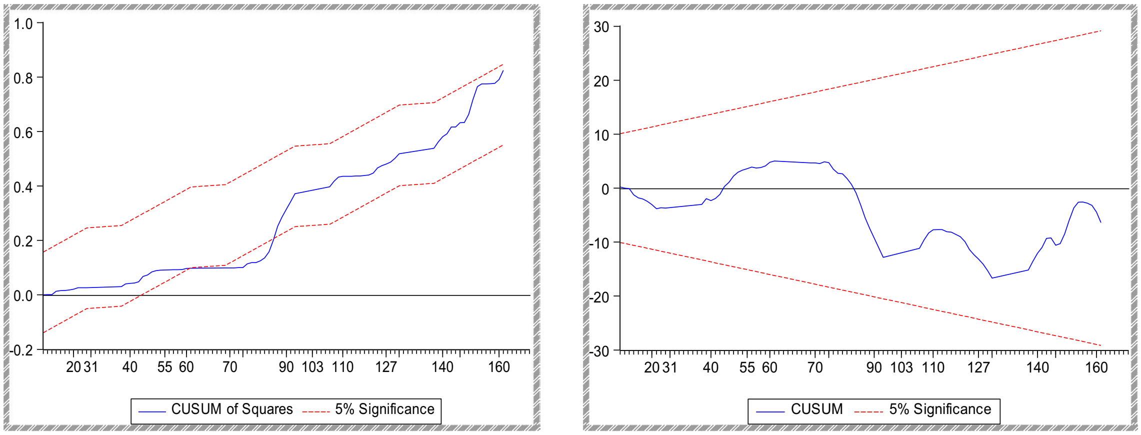

Fig. 3 Cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ)

cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) stability tests, their statistics are significant at the 5% significance level, indicating that the coefficients in the models are structurally stable.

Conclusion

This study examines the asymmetric effect of green investment, institutional quality, and GDP growth on greenhouse gas emissions in G-7 countries through the panel nonlinear autoregressive distributed lag (NARDL) model developed by Shin et al. (2014). The study covered the time span 1997 to 2020. Therefore, it is essential to go into detail about the major contributing elements and develop plans to get rid of this serious problem. Carbon emissions are the primary source of greenhouse gases, which is why the discussion of global warming has been dominated by their link with institutional quality, GDP growth, and green investments. Initially, while paying attention to the panel unit root test report, some variables were shown to be non-stationary at their levels but acquire stationarity at their first differences. Therefore, the panel unit root tests of the 2nd generation were used by (CIPS test) created by Choi (2006) and Pesaran (2007) provides results of unit root tests were also used to check the stationarity of data.

The panel NARDL results affirm that positive change in green investment (GI-POS) has positive and significant relationship with greenhouse gas emissions, while negative change in green investment (GI-NEG) has negative and significant links on greenhouse gas emissions. However, both positive and negative shocks in institutional quality have positive and significant effect on greenhouse gas emissions in long run. Furthermore, the asymmetric panel ARDL confirms that the positive shock of GDP growth has positively influence on greenhouse gas emissions, while the negative change in GDP growth shows the negative and insignificant associations with greenhouse gas emissions in long run.

Second, the Pedroni, Kao, and Fisher test results supported the long-term co-integration of the variables. Thirdly, research indicates that institutional quality, GDP growth, and green investments all directly and significantly increase greenhouse gas emissions and that this increase will further facilitate the deterioration of environmental quality. Finally, the findings of the Engel-Granger test show that there is both short- and long-term causation among the variables.

Policy implications

This study will have greatly advanced the body of knowledge on how green investment, institutional quality, and GDP growth interact. These factors are fundamentally interrelated and have an impact on one another. To encourage green investment, policymakers, economists, environmentalists, and administrators must move rapidly. As a result, it is very challenging for policymakers to cut down on greenhouse gas emissions from energy use by concentrating primarily on environmentally friendly and energy-efficient technology. It is advised that these funds be redistributed to national environmental cleanup so that they might be used for cleaner environmental development. Because foreign investment causes emissions to rise, which is not a good thing, GDP growth may demonstrate a negative shock in achieving a sustainable environment. To mitigate the negative effects of GDP growth on the environment, the government and policymakers should take the initiative and create such policies that preserve the aim to attain sustainability. Additionally, it is advised that governments and politicians take a proactive stance to promote resource acquisition and investment across all industries. To reduce gas emissions, public investments might also be complementary to private ones. So, economic policymakers, specifically in G-7 countries, should consider strategies that support sustainable economic growth. Based on the aforementioned empirical estimates, this study has important policy implications that can aid in understanding the dynamic interaction between the analyzed factors and direct policymakers to develop policies based on the studied variables. The G-7 nations are initially a distinctive combination of the world's developed and emerging economies. They make a significant maximum range of percentage contributions to institutional factors, global green investment, and GDP development. Therefore, governments in each of these nations should encourage the growth of economies that are essential for ensuring sustainable development and creating a safe and hospitable environment. Second, it is questionable whether the G-7 countries will be able to achieve the lofty target of keeping the global temperature below 28 °C despite their abundant resources and willingness to adopt newly developed forms of environmental pollution. Therefore, to achieve both the goal of combating climate change and ensuring the security of green energy, waste consumption must be reduced and phased out and replaced with renewable energy. Third, the chosen panel of nations must strengthen their cooperation and increase their support for other institutions as major international institutional players. Fourth, society and industry must become more technically advanced, which is important for lowering greenhouse gas emissions. Fifth, environmental quality should be enhanced through economic growth, which can only be done if green investment and opportunities are significantly expanded. Finally, these nations have a wealth of resources, including cutting-edge technology, renewable energy, and green development initiatives. As a result, sensible and effective use will aid in the convergence of these economies in terms of investment, consumption, and greenhouse gas reduction.

It is important to ensure that in G-7 nations, they should improve their institutional quality and reap long-term environmental benefits. In this context, it is important to base decisions on the growth of institutional elements including rule of law, civil politics, bureaucratic excellence, corruption control, and democratic freedoms. It is also crucial to note how well these institutions function. In light of this, the G-7 nations' social and political efforts to change their institutions should be stepped up. Increasing the institutional quality in these nations can be sparked by public pressure and demand for institutional reform. Then, a national strategy to strengthen areas like the fight against corruption, government accountability, good governance, and the rule of law can be devised.

Author contribution Jiguo Zhao: introduction section and writing—original draft and supervision; Saif ur Rahman: interpretation of findings and writing—original draft and supervision; Sahar Afshan: writing—literature review and methodology and data curation; Muhammad Sibt E Ali: conceptualization framework, writing original draft, and data analysis; Hammad Ashfaq: initial draft preparation, original draft, and writing—methodology; Sadia Idrees: analysis and explanation results, proofreading, and writing—original draft.

Data availability The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval This original work has not been submitted anywhere else for publication.

Consent to participate Not applicable.

Consent for publication The paper submitted with the mutual consent of authors for publication in Environmental Science and Pollution Research.

Competing interests The authors declare no competing interests.

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