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# DOES GREEN FINANCE, TECHNOLOGY AND FINANCIAL DEVELOPMENT MATTER ENVIRONMENTAL SUSTAINABILITY? NOVEL INSIGHT FROM PAKISTAN BASED NONLINEAR ARDL APPROACH

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## 1. ABSTRACT

The most significant issue confronting the world right now is environmental sustainability, especially for emerging nations that are already dealing with several problems and difficulties, among them the ecological issue. Because of this, the current study carefully examines the many elements influencing the state of the ecosystem. The primary goal of the current study, however, is to assess the asymmetrical effects of green technology, green finance, and other controllable factors on environmental deterioration in Pakistan. The study will utilize the data from 1980 to 2022 and apply the asymmetric (NARDL) approach. The outcomes of the study demonstrate that the positive shock and negative shock of green finance, technology innovations environmental sustainability ($CO_2$) and financial development have long-term, favorable, and important relationships with one another. The environment is significantly and favorably impacted by the growth of foreign direct investment. The current study, however, will examine nonlinearities that were absent from earlier investigations and led to some false

conclusions. Moreover, the outcomes of the results will recommend that policymakers make some policies in which they suggest the government should spend their expenditures on some a sustainable environment.

**Keyword:** green finance, technology, economic growth, NARDL. Pakistan

## 2. 1. INTRODUCTION

The most serious issue on the planet and the main factor in the development of catastrophic illnesses is environmental deterioration. Environmental contamination is rising as a result of mining, exploration, and industrialization. Both developed and developing countries seek to preserve the environment, although wealthy nations make more contributions. The effects of environmental pollution are harmful to people. According to (Bruce, Perez-Padilla, & Albalak, 2000)and (Bruce et al., 2000)air, land, and water pollution are the three primary categories. Additionally, environmental contamination is rising quickly globally as a result of the destruction of forests and other natural resources(Appannagari, 2006). Similar to this research "World Data Atlas Pakistan Environment" (2020) looked at how quickly environmental pollution is growing in Pakistan. The amount of $CO_2$ emitted per person in 1971 was 0.3 tones, and in 2020 it climbed to 1.04 tones. Therefore, the yearly growth rate of CO2 emissions per person is 2.63%. Furthermore, greenhouse gas emissions are a significant contributor to climate change. According to BP statistics' report on $CO_2$ emissions (2019), emissions related to the use of fossil fuels increased by 33890.799 million tons in 2018 compared to only 11,190 million tones in 1965. However, the BP report (2019) confirms that 2018 saw the fastest annual growth rate of 2.0% for carbon emissions. Pakistan is also one of the growing nations where traditional cooking techniques are used by the populace, which is quickly raising atmospheric carbon emissions. For instance, in the 19th century, carbon emissions ranged between 260 and 290 parts per million, The fast growth in $CO_2$ emissions, which have reached 385 parts per million yearly and have an average level of over 2 parts per million (U. Shahzad, Ferraz, Doğan, & do Nascimento Rebelatto, 2020) has entirely altered the situation, however. The vulnerability of Pakistan to environmental pollution further strengthened its prominence on the world stage. The energy and transport sectors are the two primary contributors to pollution, accounting for half of all pollution. Emissions of $CO_2$ in Pakistan increased from 68,242.01 (kt) in 1991 to 166,297.8(kt) in 2014 as a result of energy usage (Farooq, Ozturk, Majeed, & Akram, 2022)

The earlier literature on environmental degradation examined variables that are related to the environment, including economic development, Technology for communication and information, infrastructure for telecommunications, foreign direct investment, trade openness, oil prices, economic development, the purpose of the fiscal tool, deforestation, water scarcity, industrialization, urbanization, agricultural and forestry sectors, human capital, institutional quality, and financial development. (ICT), despite the fact that in the Pakistan region, industrialization, FDI, economic growth, and energy consumption are the most commonly addressed topics. In addition, Pakistan's economic development depends on these four factors: green financing, financial development, the agricultural sector, and technology. Therefore, the current study examines the relationship between financial development, green financing, growth in the economy, and the preservation of the environment.

Environmental pollution is significantly impacted by green money. Therefore, fiscal policy may be very important in reducing deforestation. Effective governance is also required and has been shown to have a beneficial and substantial influence on the environment (Cadman et al., 2019). Taxes, fees, and other financial penalties are insufficient fiscal tools to address the environmental problem. Although it was shown that taxes and public expenditure were two of the most significant budgetary tools, another study (Postula & Radecka-Moroz, 2020)studied the financial mechanisms utilized to mitigate environmental pollution. Similarly, (Du et al., 2020) studied second research in China to analyze the various effects of physical structure on ecological quality. They discovered that roads are the principal source of increased carbon emissions, yet by analyzing Pakistan's financial development indices, this theory seeks to identify ways to reduce carbon emissions and enhance economic growth. Given that it had Pakistan, one of the top ten countries most adversely affected by climate change in the past 20 years, experienced economic damages of US$3792.52 million and lost 0.598 percent of its GDP as a result of 152 extreme weather events between 1999 and 2018 (Global Climate Risk Index, 2021). Pakistan's annual $CO_2$ emissions per person have grown by an average of 3% annually over the past ten years (WDI, 2021). Regarding the link between rising economic activity and higher carbon dioxide emissions, researchers in Pakistan have reached a range of results. In light of the results According to several studies ((Bikbov et al., 2020; Hussain et al., 2017; Javid & Sharif, 2016; A. Raza, Muhammad, Sharif, & Atta, 2013; S. A. Raza, Shah, & Ali, 2019; Rossen, Branum, Ahmad, Sutton, & Anderson, 2020; M. W. Shahzad, Burhan, Ang, & Ng, 2017),P akistan's rising GDP is to blame for the nation's rising $CO_2$ emissions.

ICT is crucial for a sustainable environment, and developed nations use a variety of technologies to reduce environmental pollution. In addition, (Jakada, Mahmood, Ali, & Ismail Aliyu, 2023)looked at how ICT decreases $CO_2$ emissions using digital transportation systems, smart electrical grids, efficient energy use, and manufacturing development and demonstrated the link between ICT and the environment. Additionally, the demand for power in emerging nations expanded due to the greatest usage of ICT products. The management of the environmental pollution issue depends heavily on ICT indicators, such as the internet, satellites, mobile phones, and machines(Saadi, Antoni, Karimzadeh, Badri, & Aghayarihir). By producing a sizable amount of $CO_2$ emissions, it may have a negative effect on the environment. The most recent research by Shahzad et al. (2021) also examined the impacts of Pakistan's financial development, economic expansion, ICT development, energy consumption, and environment. The findings indicated that $CO_2$ emissions and ICT exhibit strong asymmetric cointegration. It indicates that there are advantages of ICT that have an adverse impact on carbon dioxide emissions.

Even though the Covid-19 pandemic has been plaguing the world for more than a year and a half, climate change is still a top worry for people all around the world. In-depth studies on the issue have demonstrated the risks associated with climate change, notably the extreme weather events that endanger both humans and ecosystems. Physical hazards and transition risks may be divided into two groups ((Dafermos, Nikolaidi, & Galanis, 2018; Rodda et al., 2021). The emission of greenhouse gases occurs during the production of commodities, indicating a strong relationship between economic activity and climate change. Governments have employed a

number of tactics over the past few decades to combat climate change, and greenhouse gas emissions have received the most attention from scientists who have studied this effort. There have been continuous arguments concerning the overall impact of FDI on environmental contamination, which can have conflicting effects on $CO_2$ emissions and environmental deterioration. Some academics claim that FDI is not only destructive but also helps to safeguard the environment. FDI that is transferred in the form of productive, efficient technology can help countries reduce air pollution(Stretesky & Lynch, 2009). Many other researchers, however, assert that FDI contributes to air pollution. According to their argument, FDI encourages economic growth by increasing productivity, which in turn increases energy consumption. Increased $CO_2$ emissions spurred on by increased energy consumption cause environmental pollution. Polluting corporations may also choose to invest in developing countries with lax environmental regulations in order to lower production costs, which increases the country's energy consumption.

Few studies have connected finance and technology, but green finance is the junction of environmentally beneficial behavior with the financial and economic world (Scholtens, 2017).According to (Shungin et al., 2015),green financing promotes investment in emerging technologies and ideas, such as renewable energy. One of the main areas of scholarly focus has always been the worth of financial growth. In previous academic studies, the idea of "sustainable development" was the starting point, and the idea of "quality of economic growth" was added throughout time. The idea of "economic growth quality" differs from the more established and common notion of "economic growth" in that it places greater focus on the twin goals of economic growth quantity and quality while also reflecting on the unfavorable effects of economic growth rate(Ren & Chao, 2018)

While some academics hold the contrary opinion and believe that the promotion of green finance would have a certain detrimental influence on economic growth (Liu Sha 2019), green finance represents a novel growing opinion and engine to help boost economic development (Liu 2020). According to several researchers that looked at the effect of green credit on economic investments in green credit may greatly support the expansion of green industries and directly contribute to regional economic growth.

The effects of technological development and economic growth on $CO_2$ emissions, respectively, have been carefully and in-depth examined by many academics. They made suitable choices based on the tasks they needed to do. The method that is most commonly used to investigate the relationship between economic growth and $CO_2$ emissions is the Environmental Kuznets Curve (EKC), which was initially created by Crossman and Krueger (1992). According to the vast majority of academics technological innovation aids in reducing $CO_2$ emissions and improving environmental quality. For instance, stronger environmental regulation has been linked to an increase in direct environmental solutions for lowering $CO_2$ emissions. In conclusion, the association amid technical innovation and $CO_2$ emissions is debatable, indicating that it merits additional investigation. The presence of heterogeneity also shows that it may be examined on a larger scale, rather than being restricted to a small number of industrialized nations. Most notably, when analyzing a panel sample, relevant research has

seldom taken geographical dependency or spillover effects into account. In reality, a few research ((Gianmoena & Rios, 2018)have verified the geographical association of $CO_2$ emissions among nations.

The development of both industrialized and emerging nations is greatly influenced by economic expansion, which also contributes significantly to $CO_2$ emissions. Environmental contamination is another major issue facing the entire planet. Although they priorities economic expansion over environmental quality, rising economies are more impacted and have a positive and considerable influence on CO2 emissions(Gold et al., 2020). Furthermore, recent research (Zhang, Bengio, Hardt, Recht, & Vinyals, 2021)analyzed the detrimental effect of GDP on $CO_2$ emissions since, in the course of economic growth and development, enormous amounts of gas, sewage, and waste emissions are created that have impacted the environment's air quality. Additionally, (Majeed, Wang, Zhang, & Kirikkaleli, 2021)examined the rise in energy consumption (oil, gas, and coal consumption has a degrading influence on environmental quality) and shown the negative and considerable impact of economic expansion on carbon emissions in Pakistan.

The primary cause of climate change is the use of fossil fuels by the manufacturing sector. Fuels like petrol, oil, and coal produce harmful fumes when they are burnt, which has led to environmental damage. Pakistan's primary source of electricity production is oil. Oil-based electricity generates greenhouse gases and has a detrimental effect on the environment(Qureshi et al., 2016). Furthermore, (Salem et al., 2020)determined that energy consumption has a detrimental effect on Pakistan's sustainable environment; they demonstrated the sizeable and detrimental role that power consumption has in environmental degradation. The current study carefully examined the literature review on the intersection of ICT, green finance, and CO2 emissions, and it found a linear relationship. While the majority of macroeconomic factors, particularly business cycles, had nonlinear characteristics, carbon emissions were really only assessed using a linear framework(Neftci, 1984). Additionally, the fundamental problem with the linear time series model is that variables are assumed to be linear, despite the fact that most time series contain nonlinear characteristics. Additionally, (Meo, Chowdhury, Shaikh, Ali, & Masood Sheikh, 2018)investigated the linear time series framework and demonstrated a few false conclusions. Therefore, there is a critical requirement to assess the unequal relationship between green finance and financial growth because of the significance of nonlinear inference in the time series model.

## 2. Literature Review

According to the findings of these studies, a growth of the economy makes it easier for consumers to get loans in order to purchase $CO_2$-emitting appliances such as refrigerators, motorcycles, automobiles, and air conditioners. On the other hand, local and foreign investors participate in projects with lower transaction costs without considering $CO_2$ emissions, which ultimately has a negative impact on the environment. The OECD is an organization that promotes economic cooperation and development. studied economic growth, technical advancement, and direct investment from other countries. According to the findings, a higher

rate of technological innovation is associated with lower levels of carbon dioxide emissions (Awan, Rahman, Ali, & Zafar, 2023; Chaudhary, Nasir, ur Rahman, & Sheikh, 2023; Dawood, ur Rehman, Majeed, & Idress, 2023; A. U. Shahid et al., 2022; Shahzadi, Sheikh, Sadiq, & Rahman, 2023; Zahra, Nasir, Rahman, & Idress, 2023)all shown that advances in technology had a negative impact on emissions of carbon dioxide. Haider and Khan (2018) conducted research to evaluate the worldwide impact that increasing GDP, engaging in international commerce, and using more energy have on carbon dioxide (CO2) emissions.(Hossain, 2011)conducted experiments to investigate the fluid causal relationships between carbon dioxide emissions, energy use, economic growth, trade openness, and urbanization for his 2011 article. (Amin, Aziz, & Liu, 2020)looked at the relationship between trade openness, urbanization, and $CO_2$ emissions., and technological innovation using panel data from thirteen Asian nations from 1985 to 2011. The time period covered in their study was from 1985 to 2011 (Qi & Zhang, 2011).

## 2.1 Theoretical Literature

In their 2017 study, Zhang, Liu, and Bae investigated whether the environmental Kuznet curve (EKC) existed or not and how trade openness affects $CO_2$ emissions, real GDP, and overall primary energy consumption. The research sample consists of ten newly industrialized nations (NICs-10) between 1971 and 2013. The results support the existence of the GDP hypothetical EKC and demonstrate that, whereas real GDP and energy have a positive influence on emissions, trade openness has a negative and significant impact on emissions. Additionally, unidirectional relationships between trade and energy are shown through empirical studies of short-run causalities, as well as possible feedback connections between real GDP and emissions. long-term feedback connections between trade openness, real GDP, and emissions are shown by the error correction terms (ECTs), but energy Granger causes The findings indicated that the rise in $CO_2$ emissions was mostly due to economic system development, with urbanization and the financial sector's expansion coming in second and third. However, the utilization of renewable energy was not as high as it could have been to reduce carbon dioxide emissions. Furthermore, evidence was discovered to support the environmental Kuznets curve (EKC) theory, which claimed a U-shaped relationship between economic development and $CO_2$ emissions. Because of the importance of $CO_2$ emissions in environmental degradation and their repercussions on all economic and financial sectors, numerous researchers have chosen to include specific possible indicators in order to scientifically validate the EKC hypothesis. Zhang, Liu, and Bae investigated the truth or fiction of the environmental Kuznet curve (EKC) and the consequences of trade openness on $CO_2$ emissions, real GDP, and overall primary energy consumption in their 2017 study. The findings show that the GDP hypothetical EKC is real and that trade openness has a considerable negative impact on emissions, but real GDP and energy consumption have little effect.

## 2.2 Empirical Literature

### 2.2.1 Carbon Emission & Financial Development

Moreover,(Omri, Daly, Rault, & Chaibi, 2015)offer the results of an empirical research that was carried out between 1990 and 2011 on 12 nations in the MENA area. These findings confirm that there is minimal relationship between economic development and carbon emissions. (Kang et al., 2017)conducted research on China's 30 provinces, cities, and autonomous areas between 1997 and 2013. They looked at how the structure and evolution of the financial system affected carbon emissions. As the research took into account such a broad variety of structural and developmental features of the financial system, its conclusions are all over the place. They arrived to the conclusion that various structural indicators and elements of China's economic development cause carbon emissions to rise in some regions but not in others. Also, between 2001 and 2014, (Xing et al., 2017)did research in China. According to how They developed a financial development index, looked at its impact on carbon emissions in 30 Chinese provinces, and divided the provinces into four groups. The provinces were then compared to one another in terms of both financial development and carbon emissions. The findings demonstrate that environmental improvements made in the financial sector are harmful to the environment both immediately and long-term.

(Amjad, Asghar, & Rehman, 2021) looked at the connection between pollution and financial development as well as the expansion of the economy. The 1980s to 2020 era was included in the investigation. The Non-linear Autoregressive Distributed Lag (NARDL) econometrics approach results reveal that positive financial development shocks increase economic growth and reduce pollution. Notwithstanding the fact that the negative shocks brought on by financial development enhanced pollution and economic growth. Globalization has had a detrimental effect on economic development since higher energy consumption causes both increased economic growth and more environmental damage. In order to encourage private investors to employ low-carbon technology, The State Bank of Pakistan and other financial institutions are advised to create and implement policies that provide more flexible funding.

(L.-L. Lv et al., 2020)explored how financial development affected $CO_2$ emissions using a regional econometric model using panel data from 97 countries between 2000 and 2014. They were able to do this by using the model to analyze data collected between 2000 and 2014. According to the figures, there was a spatial correlation between the amounts of carbon dioxide emissions produced in the various countries during the course of this time period. More importantly, we found that the economic development of a country's neighbors may have an impact on its carbon dioxide emissions. Particularly, the extremely positive direct effect of financial development on $CO_2$ emissions was offset by the very negative indirect effect, indicating a strongly negative overall effect (Rasool et al., 2022). This developed as a result of the direct impact, which was quite helpful. The relationship between financial development and $CO_2$ emissions has been the topic of much research, although no consensus has been reached (M. Ahmad et al., 2022; Hafiza et al., 2022; Shahid, Muhammed, Abbasi, Gurmani, & ur Rahman, 2022; Zulfiqar et al., 2022).

### 2.2.2 Carbon Emission & Foreign Direct Investment

Using Pakistani data from 1980 to 2014, (Bakhsh, Rose, Ali, Ahmad, & Shahbaz, 2017)came to the statistically significant and favorable conclusion that FDI had a favorable influence on $CO_2$ emissions. (Bilal, Shah, Rahman, & Jehangir, 2022)used several cointegration techniques to analyses data from 1974 to 2013 to investigate how FDI has affected $CO_2$ emissions in the case of Turkey. The results show that FDI lowers $CO_2$ emissions. Additionally,(Bilal et al., 2022) got equivalent results for 15 independent post-Soviet Union countries using the system GMM technique. Furthermore,(Li et al., 2022) showed that there is a bidirectional causal link between FDI and $CO_2$ emissions for Turkey using data spanning the years 1974–2010. Additionally, they deduce that Turkey adheres to the EKC hypothesis. For the Malaysian example, the long-run elasticity of $CO_2$ emissions with respect to FDI is found to be 0.07, FDI has favorable long- and brief-term impacts on $CO_2$ emissions, according to Lau et al. (2014), who demonstrate statistically meaningful and significant effects. In contrast,(Frutos-Bencze, Bukkavesa, & Kulvanich, 2017) evaluated the influence of FDI on $CO_2$ emissions for the Dominican Republic and members of the Central American Free Trade Agreement from 1979 to 2010. The results showed that FDI has a negative impact on $CO_2$ emissions. The Gulf Cooperation Council (GCC) nations were studied from 1990 to 2014, (Rehman, Ali, Idrees, Ali, & Zulfiqar, 2022)found an adverse association between FDI and $CO_2$ emissions.

(Ghazouani, Jebli, & Shahzad, 2021)investigated the symmetric and asymmetries impacts of real GDP per capita, FDI inflow, and crude oil price on $CO_2$ emission in Tunisia for the years 1972 to 2016. The outcomes of the cointegration tests, notably the ARDL and NARDL bound tests, revealed the long-term connections between the variables. The ECK hypothesis for Tunisia was validated by the long-term outcome of both techniques. Asymmetric research revealed that economic growth and the price of crude oil had a detrimental influence on the environment, in contrast to FDI inflows that over time reduced $CO_2$ emissions. However, the asymmetry study revealed that although higher crude oil prices are bad for the environment, lower crude oil prices are good for the environment. According to the causality study, there is a one-way causation between FDI inflows and carbon emissions, as well as a bidirectional relationship between economic growth and carbon emissions. As a result, certain policy suggestions have been developed to aid Tunisia in lowering its carbon emissions and promoting economic growth. Evidence is still lacking about the connection between FDI inflows and environmental deterioration. According to certain data such as that from (Amzad Hossain et al., 2022; Usman, Rahman, Shafique, Sadiq, & Idrees, 2023)FDI inflows have a beneficial impact on $CO_2$ emissions. This group of research is closely related to the well-known "pollution haven hypothesis," which claimed that high-pollution industries were relocated by multinational corporations to developing nations, where they generated more environmental pollution (Copeland & Taylor, 1994).

### 2.2.3 Carbon Emission & Green Finance

To ascertain the construction among green financing and carbon dioxide ($CO_2$) emissions, (Meo & Abd Karim, 2022)conducted a study in the top 10 countries that support green financing (Japan, United States, Canada, Switzerland, New Zealand, Denmark, Norway, Sweden, Hong Kong, and the United Kingdom,). Using a method called quantile-on-quantile regression (QQR), which (Shafique, Rahman, Khizar, & Zulfiqar, 2021)initially devised, this study examined the distribution of the link between carbon dioxide emissions and sustainable finance. Despite knowing there is a global adverse relationship between funding for green projects and $CO_2$ emissions, we also found that the intensity of this relationship varied among the quantiles of both of these variables. This result defies our initial assumption.

### 2.2.4 Carbon Emission & Technology Innovation

Government organizations and businesses are investing heavily in research and development to create clean energy solutions in order to increase the efficiency of capital goods and save energy. Innovative technology can efficiently reduce $CO_2$e. Numerous empirical investigations that looked at the innovation-pollution nexus from various angles were made possible by existing theory and research. (Sufiyan, Haleem, Khan, & Khan, 2019)examined the relationship between urbanization, energy usage, R&D investment, and environmental pollution for China. The results confirmed that R&D investment is essential for lowering $CO_2$. These findings were in line with the following research projects (Jin, Li, Zhou, Wanatowski, & Piroozfar, 2017) carried out for the Chinese energy industry. The ordinary least squares approach (OLS) was used by (Fernández, López, & Blanco, 2018)to calculate the impact of innovative activities on CO2e in emerging countries. According to the authors, there is a negative correlation Emissions of carbon dioxide and creative endeavors. Using the GMM technique, (Su & Moaniba, 2017)concluded that changes in non-renewable fuel sources (mostly petroleum and natural gases) reduced the amount of $CO_2$ that solid fuels produced. Recent studies have found an adverse relationship between innovation and $CO_2$ in the US (Ali, ur Rahman, & Anser, 2020; Rahman, Chaudhry, Meo, Sheikh, & Idrees, 2022; Ullah, ur Rahman, & Rehman, 2023; Zahra et al., 2023; Zhu, Fang, Rahman, & Khan, 2023)and OECD economies.

The manufacturing sector plays an important part in the decrease of $CO_2$ emissions and is accountable for 70% of China's total energy-related $CO_2$ emissions. The industry played a significant role in the reduction of $CO_2$ emissions and is accountable for 70% of China's total energy-related $CO_2$ emissions. Using panel data from China's 30 provinces between 1999 and 2011, this study studied the influence of multiple technical parameters on industrial $CO_2$ intensity. Domestic research and development (R&D) tasks, spillovers from more openness, and interregional R&D spillovers—factors (Ali et al., 2020; Ilyas, Banaras, Javaid, & Rahman, 2023; Komal et al., 2023; Saleem et al., 2022; Usman et al., 2023)did not adequately discuss—were among them.

The results show that increased trade and foreign direct investment (FDI) have no net positive effects on $CO_2$ intensity. Instead, regional R&D spillovers and locally produced R&D were statistically significant and may lower the industrial CO2 intensity. However, the two effects are interdependent, demonstrating a double effect of raising local R&D intensity: on the one

hand, increasing local R&D intensity will increase its favorable effect on $CO_2$ intensity; on the other hand, increasing local R&D intensity will also increase the capacity to exploit R&D spillovers from neighboring provinces. Based on the previous findings, this study suggested regional policies that encouraged technology spillovers while simultaneously improving local innovation ability, particularly in inland regions.

**2.2.5 Carbon Emission & Trade Openness**

(M. H. Ahmad et al., 2019) employed panel data from 13 Asian countries spanning the period from 1985–2019 to look at the ever-changing connection between $CO_2$ emissions, trade openness, and technological innovation. The study's major focus was on the dynamic connection between $CO_2$ emissions, trade openness, and technological innovation. The nature of the causal links between the relevant variables is further examined using the estimate of a panel VECM model. The panel cointegration analysis revealed that there was a persistent relationship between the variables. Rising energy usage is a factor in increased $CO_2$ emissions, according to estimations from FMOLS. Despite the fact that urbanization, greater trade openness, and technological progress all help lower $CO_2$ emissions, this is still the case. According to studies on the panel causality between urbanization and emissions, technology and emissions, trade and emissions, and trade and technology, there is a long-term, two-way interaction between these four variables. The overall results are favorable. the idea that attaining environmental sustainability depends on urbanization, technological development, and trade openness.

(H. Lv et al., 2018)evaluated data acquired from 55 middle-income countries between the years 1992 and 2012 to determine The effect of open commerce on $CO_2$ emissions. The study concluded that growing commerce has a short-term favorable effect on the environment but a long-term detrimental effect on the health of the ecosystem. (Yaseen, Mansoor, Ansari, Hussain, & Khan, 2018)used annual data from 1971 to 2013 to assess the effects of economic development, global trade, and energy use on $CO_2$ emissions. The analysis covered the decades from 1971 to 2013. This is done with a focus on time series data in particular. In addition, the limits testing approach for cointegration with breakage and the unit root test with a structural break are investigated and addressed. Once this phase is done, the Granger causality test's direction of causation is determined using a vector error correction model. The authors' research indicates that energy consumption and carbon dioxide ($CO_2$) emissions are causally linked over a long period of time in a number of nations, including the United States of America, Canada, Iran, Saudi Arabia, the United Kingdom, Australia, Italy, France, and Spain. According to the results of past studies, our study showed that there is a long-term connection between the sources of $CO_2$ emissions in these nations and those emissions themselves. The authors propose that trade should be controlled in order to reduce $CO_2$ emissions since they believe that trade is a factor that, over time, causes increased $CO_2$ emissions. Over the long and medium phrases, trade liberalization has a positive direct influence on CO2 emissions, but it also has a negative indirect impact, at least initially. This is because increased $CO_2$ emissions from other sources are a result of trade liberalization. The findings highlight the necessity for strong environmental rules to be established in tandem with new trade policies, even when they are positive in the long and medium term.

**Material and methods**

The $CO_2$ emissions (a proxy for environmental degradation), financial development (FD), technological innovation (TI), trade openness (TO), green finance (GF), and foreign direct investment (FDI) inflows are all based on yearly data in this study. Technology innovation (TI) is measured in kg of oil equivalent per capita, whereas the $CO_2$ is measured in kilo tones (kt). BoP, current US dollars are used as the FDI inflow measurement unit. The spot pricing for crude oil: Oklahoma-Cushing West Texas Intermediate (WTI) (source: Energy Information Administration of the U.S. Department of Energy). The World Bank (2020) is the source of all the statistics except for the price of crude oil. The analysis spans the years 1986 to 2014 based on the data that are currently available. Table 1 lists the variable's definition, measurement method, and data source as follows: the nonlinear autoregressive distributed lag (NARDL) mode proposed by(K. Shin et al., 2014),and the (Flint et al., 1986)kinked exponential growth model land Hatemi-J (2012) test for asymmetrical causation are also discussed in this section. To investigate the asymmetric effect of the factors on carbon emissions, the nonlinear ARDL approach is applied. The following is the goal of this evaluation strategy:

(i) It enables the cointegration and nonlinear asymmetry to be combined in a single equation. The NARDL model investigates the impact of the deconstructed variables' positive and negative variations on the dependent variable. (ii) The model may be used with small sample sizes. (iii) It is adaptable since the variables do not have to be integrated in the same sequence. (iv) It is fundamentally a dynamic error correction representation that, despite the tiny sample size, yields solid empirical results.

## 3. Data, model, and econometric techniques:

### 3.1 Data and Variables:

The study used five variables and examines the effects of economic growth, FDI, technology (ICT), and environmental sustainability, such as green finance, finance development, and green finance on environmental pollution. Additionally, this study assesses Pakistan's yearly data, which was gathered from the "World Bank Indicator and Economic Survey of Pakistan" between 1980 and 2021.

| Variables | Symbols | Proxies/ Measurement of variables | Data-Source |
|---|---|---|---|
| **Environmental sustainability** | ES | "$CO_2$ emissions from transport (% of total fuel combustion)" | World development indicator |
| **Green Finance** | GF | | |

| | | | |
|---|---|---|---|
| | | Green Finance (% renewable energy consumptions) | Economic Survey of Pakistan |
| **Technology (ICT)** | ICT | "Mobile cellular subscriptions (per 100 people), Fixed telephone subscriptions (per 100 people) | Economic development indicator |
| **Economic Growth** | EG | Economic growth annual %) | World development indicator |
| **Financial development** | FD | GDP per capita at constant US$ | World development indicator |
| **Foreign direct Investment** | FDI | constant US$ | World development indicator |

Table 1: Unit of Measurements

As was mentioned in Section 1 above, previous studies have traditionally examined the relationship between green finance, technology (ICT), Several time series techniques, including Granger causality, cointegration, vector error correction model, unencumbered VAR model, and traditional ARDL, were used to study the connection between financial development, foreign direct investment, and carbon emissions (Usman, Zarebanadkouki, Waseem, Katsoyiannis, & Ernst, 2020).In addition, the methods shown above are the sole ones employed for the linear time series relating to $CO_2$ emissions and funding for and environmentally friendly technologies. The ARDL-based cointegration looks at only produced long-run and short-run findings; however, it was unable to reveal the variables' nonlinear interactions(Howe et al., 2021). In addition, public investment and energy frequently exhibit nonlinear cyclical conduct, according to (Deaton, Bauguess, Huffman, & Miller, 1996).The study utilized a nonlinear (NARDL) approach to identify the asymmetric relationship between the variables (Shin, Yu, & Greenwood-Nimmo, 2014).According to (Pesaran, Shin, & Smith, 2001),the nonlinear technique is a variant of the linear approach (ARDL). The nonlinear (NARDL) bound testing cointegration approach also divides green finance, technology (ICT), financial development, and foreign direct investment into positive and negative shocks to find their effects on carbon emissions, in contrast to the conventional ARDL approach that just finds the positive or negative shocks at the same time. For instance, the asymmetric technique provides links between the variables of interest over both short and long time periods. The

current study also analyses the various models and evaluates the long- and short-run relationships among the variables as it follows the long-run equation shown below (Chowdhury, Paul, Kaisar, & Moktadir, 2021).

$$X_t = Y_0 + \alpha_1(Y_t) + \mu_t \qquad \textbf{(1)}$$

In the equation above, Y stands for independent variables including green finance, technology (ICT), financial development, and foreign direct investment, whereas X stands for dependent ones like as ES and economic growth at time t. Also, one may investigate the assessment of linear cointegration (ARDL) for independent and dependent variables as

$$\Delta X_t = \alpha_0 + \alpha_1 X_{t-1} + \alpha_2 Y_{t-1} + \sum_{J=1}^{k-1} \alpha_3 \Delta X_{t-J} + \sum_{J=1}^{k-1} \alpha_4 \Delta Y_{t-J} + \mu_t \qquad (\mathbf{2})$$

In the aforementioned equation, the long-run coefficients are _1 and _2, whereas the short-run coefficients are _3 and _4. In the current inquiry, the Schwarz information criterion (SIC), also known as K in the equation above, was replaced with the ideal delays. The test for the absence of cointegration, denoted by _1= _2 = 0 in equation 2, is also represented by the (Chowdhury et al., 2021)linear (ARDL) model. The traditional linear framework time series model also had a lot of advantages, and it worked especially well with small amounts of data (Romilly, 2001). However, Ibrahim et al. (2015) claim The traditional-based correlation approach and the linear (ARDL) cointegration methodology are not equal. We may continue using the ARDL approach after all the variables are stationary at level I (0) or first difference I (1) have provided mixing results at the first difference. Additionally, if the variables are stable at the second difference, the ARDL approach is inadequate for linear cointegration (MS et al., 2018). Additionally, (Grossman & Razin, 1984)said that the ARDL cointegration approach does not capture positive and negative shocks indicated in the long-run period and presented the concealed cointegration that exists among the purposed variables. For instance, Yann Schroeder created a NARDL regression model and outlined the hidden cointegration in it in great detail. Similarly, to this, (Crews et al., 2014)NARDL cointegration model is shown as follows:

$$X_t = \varphi + \varphi^{+} y_t^{+} + \varphi^{-} y_t^{-} + \mu_t \qquad \textbf{(3)}$$

Where Y is represented as exogenous variables and divided into positive and negative shocks as shown in the following equation, the + and - are designated as long-run coefficients.

$$X_t = X_0 + X_t^{+} + X_t^{-} \qquad \textbf{(4)}$$

Equation (2) may be expressed as follows when explanatory variables undergo logarithmic transformation with both positive and negative changes:

$$lnCO_{2_t} = \alpha_t + \delta_t + \beta^{+} \ln FD_t^{+} + \beta^{-} \ln FD_t^{-} + \beta^{+} lnTO_t^{+} + \beta^{-} lnTO_t^{-} + \beta^{+} \ln TI_t^{+} + \beta^{-} \ln TI_t^{-} + \beta^{+} \ln GF_t^{+} + \beta^{-} \ln GF_t^{-} + \beta^{+} lnFDI_t^{+} + \beta^{-} lnFDI_t^{-} + u_t \qquad (3)$$

Where ln is the natural logarithm, is the trend effects, s are the variable coefficients, and is the error term with time t. The framework of Eq. (3) known as the nonlinear autoregressive distributed lag (NARDL) may be stated as follows:

$$\Delta ln CO_2 = \mu + \rho ln CO_{2_{t-2}} + \theta^+ ln FD^+_{t-1} + \theta^- ln FD^-_{t-1} + \vartheta^+ ln EG^+_{t-1} + \vartheta^- ln EG^-_{t-1} + \omega^+ ln TI^+_{t-1}$$
$$+\omega^- ln TI^-_{t-1} + \varphi^+ ln GF^+_{t-1} + \varphi^- ln GF^-_{t-1} + \varphi^+ ln FDI^+_{t-1} + \varphi^- ln FDI^-_{t-1}$$
$$+\sum_{j=1}^{n-1} \alpha j \Delta ln CO_{2_{t-j}} + \sum_{j=0}^{n_2} \left(\pi^+_j \Delta ln FD^+_{t-j} + \pi^-_j \Delta ln FD^-_{t-j}\right) \sum_{j=0}^{n_3} \left(\vartheta^+ ln EG^+_{t-1} + \vartheta^- ln EG^-_{t-1}\right)$$
$$+\sum_{j=0}^{n_4} \left(\omega^+ ln TI^+_{t-1} + \omega^- ln TI^-_{t-1}\right) + + \sum_{j=0}^{n_5} \left(\omega^+ ln GF^+_{t-1} + \omega^- ln GF^-_{t-1}\right) + \sum_{j=0}^{n_6} \left(\varphi^+ ln FDI^+_{t-1} + \varphi^- ln FDI^-_{t-1}\right) + \in_t \quad (4)$$

The following equation may be used to calculate the short-run NARDL elasticities with error correction

$$\Delta ln CO_2 = \mu + \sum_{j=1}^{n-1} \alpha_j \Delta ln CO_{2_{t-j}} + \sum_{j=0}^{n_2} \left(\pi^+_j \Delta ln FD^+_{t-1} + \pi^-_j \Delta ln FD^-_{t-1}\right)$$
$$+\sum_{j=0}^{n_3} \left(\vartheta^+ ln EG^+_{t-1} + \vartheta^- ln EG^-_{t-1}\right) + \sum_{j=0}^{n_4} \left(\omega^+ ln TI^+_{t-1} + \omega^- ln TI^-_{t-1}\right)$$
$$+\sum_{j=0}^{n_5} \left(\omega^+ ln GF^+_{t-1} + \omega^- ln GF^-_{t-1}\right)$$
$$+\sum_{j=0}^{n6} \left(\varphi^+ ln FDI^+_{t-1} + \varphi^- ln FDI^-_{t-1}\right) + \varnothing ECM_{t-1} + \in_t \quad (5)$$

## 3. 4.EMPIRICAL RESULTS AND FINDINGS:

The present research scrutinizes the descriptive statistic, and unit root test and then evaluates the asymmetric long-run and short-run results in this section.

### 4. 4.1 DESCRIPTIVE STATISTIC RESULTS

Table 2 illustrates descriptive statistics findings, which indicate that the mean of EG and FDI is lower than that of FD, TI, and GF. The "Jarque-Bera" test determines if the data are normal and also shows that, with the exception of the variable of FD, all variables are more significant than 1%. for their excellent performance. Moreover, Table 2 examines the FD and TI are positively skewed, while the FDI, EG, and GF are negatively skewed. Furthermore, Kurtosis shows all variables underlying Leptokurtosis.

**Table 2 Descriptive statistic**

| | FD | TI | FDI | EG | GF |
|---|---|---|---|---|---|
| Mean | 3.432 | 3.576 | 2.138 | -0.115 | 2.273 |
| Median | 3.430 | 3.558 | 2.142 | -0.110 | 2.142 |
| Maximum | 2.542 | 3.725 | 2.109 | 0.317 | 2.185 |
| Minimum | 3.524 | 3.477 | 2.014 | -0.614 | 1.826 |
| Std. Dev. | 0.005 | 0.050 | 0.063 | 0.233 | 0.190 |
| Skewness | 0.511 | 0.192 | -0.465 | -0.145 | -1.221 |
| Kurtosis | 1.572 | 1.723 | 1.416 | 1.873 | 3.322 |
| Jarque-Bera | 17.631 | 9.429 | 5.744 | 2.664 | 19.521 |
| Probability | 0.000 | 0.354 | 0.113 | 0.142 | 0.336 |

## 5. 4.2 FINDING OF UNIT ROOT TEST:

The present study applies the two famous tests "Augmented Dickey-Fuller (1979) and Philip Peron (1988)" for scrutinizing the stationary of the variables. Tests of "ADF and PP" demonstrate that although the LNREN_GF is stationary at levels and at the first difference, all variables are stationary at the first difference. At 1% and 5% levels of significance, respectively, the ** and *** means variables are stationary. Additionally, the data assesses the mixed findings, indicating that the current study will proceed with unequal long- and short-run cointegration among the variables.

**Table 3 Unit Root Test**

| Variables | Unit root at level I(0) | | Unit root at first difference I(1) | |
|---|---|---|---|---|
| | ADF | PP | ADF | PP |
| FD | (0.567) | (0.478) | (0.000)*** | (0.000)*** |
| TI | (0.367) | (0.541) | (0.000)*** | (0.000)*** |
| FDI | (0.591) | (0.579) | (0.000)*** | (0.000)*** |
| EG | (0.919) | (0.477) | (0.000)*** | (0.000)*** |
| GF | (0.069)** | (0.027)** | (0.000)*** | (0.000)*** |

With intercept and intercept and trend applied first at the level and then at the first difference, the augmented Dickey-Fuller (ADF) and Philip Peron (PP) unit root tests have been conducted. The lag duration was chosen using the SBIC, and the significance levels (in parenthesis) * and ** are 1% and 5%, respectively.

## 6. 4.3 BOUND TEST OF LINEAR AND NONLINEAR COINTEGRATION:

Table 4 exhibits the outcomes of the cointegration method's symmetric and asymmetric bound testing. The results display the linear and nonlinear cointegration F-statistic data. Because the F-statistic computed value (0.836) is less than the lower bound value of 2.53 at a level of 1% significance, the linear (ARDL) F-statistic value indicates an inconclusive conclusion. Therefore, the nonlinear F-Statistic calculated value (4.145) is greater than the upper bound

observation, and this information shows a nonlinear relationship between the variables, indicating hidden cointegration between the exogenous variables of GF, FDI, TI, FD, and EG and the sustainability of the environment (CO2 emission). The long-run and short-run link between the endogenous and exogenous variables is encouraged by the information currently available on cointegration among the variables.

**Table 4 Bound test for linear and non-linear cointegration**

| | | | Critical values bounds | | |
|---|---|---|---|---|---|
| **Test-Statistic** | **F-Statistic** | **Sig. level** | **Lower bound at 5%** | **Upper bound at 5%** | **Decision** |
| **Linear ARDL** | **0.836** | **1%** | 2.53 | 3.68 | Inconclusive |
| **Asymmetric ARDL** | **4.145** | **5%** | 2.02 | 3.24 | Cointegration exists |
| | | **10%** | 1.74 | 2.96 | |

Note: The critical value of linear-ARDL from (Pesaran et al., 2001). *,** and *** are represents the 1%, 5%, and 10% significance levels of critical bound values, the value of F- Statics is greater than the upper bound value which confirms the strong cointegration relationship. The null hypothesis of asymmetric cointegration is $p = \theta^{+} = \theta^{-} = 0$

**4.4 Asymmetric short-run estimations.**

The Table.5 The goal of the current study is to explain the short-run dynamic estimation result. According to the short-run equation, the dependent variable LFD (-1)'s coefficient is -0.070, with a significance level of 1%, and the negative sign indicates that the variables in the current model have a long-run relationship. Therefore, in the short term, "green finance" shocks—both positive and negative—are important. Accordingly, a 1 unit rise in green financing will result in an increase of 0.042 units of the environment sustainability ($CO_2$ emission) because green finance gives the opportunities in the shape of loans, and green project and these factors help to improve the carbon emissions and also supports to increase in the environment sustainability ($CO_2$ emission). Likewise, the negative shock of green finance evaluates the 1 unit decrease the green finance will lead to a decrease the 0.08 units of environment sustainability which means negative shock will slow the process of the environment sustainability ($CO_2$ emission) in the short run. Therefore, the positive shock of the industry is significant and a 1 % increase

in the industry's activities will lead to an increase the environment sustainability ($CO_2$ emission) which means the companies used some clean technologies or renewable energy which helps to increase the environment sustainability ($CO_2$ emission) procedures. While negative shocks in the industry will decrease the environment sustainability ($CO_2$ emission) in the short run. Moreover, positive changes in environmental technology will improve the environment sustainability ($CO_2$ emission) process. However, the negative shock shows a great impact on environment suitability and also increases the $CO_2$ emissions in the Pakistan. Furthermore, the positive renewable energy increases the process of the environment sustainability ($CO_2$ emission). while negative shock has an inverse relationship with the environment sustainability ($CO_2$ emission) and also diereses the environment sustainability ($CO_2$ emission) process in the short run.

**Table 5 Asymmetric short-run results**

| Variable | Coefficient | t-Statistic | Prob. |
|---|---|---|---|
| C | 0.470 | 2.334 | 0.026** |
| FD(-1)* | -0.070 | -2.14 | 0.026** |
| GF_POS** | 0.042 | 2.496 | 0.012** |
| GF_NEG** | 0.008 | 4.131 | 0.021** |
| FDI_POS(-1) | 0.015 | 1.28 | 0.024** |
| FDI_NEG(-1) | -0.073 | -3.879 | 0.035** |
| EG_POS(-1) | -0.006 | -2.777 | 0.033** |
| EG_NEG(-1) | -0.314 | -5.034 | 0.096* |
| TI_POS(-1) | -0.083 | -1.688 | 0.114 |
| TI_NEG(-1) | -0.092 | -0.591 | 0.521 |
| D(FDI_POS) | 0.321 | 9.651 | 0.000*** |
| D(FDI_NEG) | -0.139 | -6.184 | 0.000*** |
| D(EG_POS) | 0.019 | -8.624 | 0.000*** |
| D(EG_NEG) | 0.001 | 3.514 | 0.003** |
| D(GF_POS) | 0.078 | -6.452 | 0.000*** |
| D(GF_NEG) | -1.427 | -4.148 | 0.000*** |

Notes: ***, **, * Asterisk indicates the level of significance at 1%, 5%, and 10% respectively. Whereas, the value of the dependent variable LNWW_FD (-1) is denoted by the lag (1). While the POS and NEG indicate the positive and negative shocks of independent variables on the dependent variable respectively. The present study finds all the parameters in the model are stable (Smith et al., 1990)

### 4.5 The asymmetric results of long-run:

Table.6 reported the nonlinear long-run relationship among the variables. The coefficients of GF_POS and GF_NEG are 0.060 and 0.068 respectively and significant at a 5% level of significance respectively which means an asymmetric relationship exists between the variables. Furthermore, a 1% increase in "green finance" will leads to an increase in the 0.060 units of the environment sustainability ($CO_2$ emission) in the Pakistan. For instance, the government of Pakistan should give the opportunities to the investors to make some projects for Technology

innovation and green finance has a significant impact on the environment sustainability ($CO_2$ emission) treatment which helps to enhance the sustainable environment(Smith et al., 1990). Moreover, the negative shock of green finance has a significant relationship which means a 1% decrease in "green finance" will decrease the 0.068 units of the environment sustainability ($CO_2$ emission) which means the financial market is not stable, and investors or companies have no capital to invest in activities which help to reduce the $CO_2$ emission. Furthermore, the positive shock of "foreign direct investment" shows a positive and significant impact at a 5% level of significance which means a 1% increase in FDI will lead to increases in the 0.031 $CO_2$ emissions because the 4.0 industry uses some clean technology which slow the process of environment sustainability and increases the $CO_2$ emissions. Likewise, the negative shock of the FDI will reduce the procedure of $CO_2$ emissions and has the inverse relationship between them which means a 1% decrease in the foreign direct investment will lead to a decrease in the 0.318 of $CO_2$ emissions. However, the results indicate the industry that has not used clean energy due to import and less foreign investment which causes by contaminated pollution in the long run period and this polluted the environmental quality. In the same line, approximately 93.45 mg/kg of heavy metals are discharged into the water from industrial production and decontaminated into the environment(Thomas et al., 2021).

**Table. 6 Asymmetric long-run results**

| Variable | Coefficient | Prob. |
|---|---|---|
| FD_POS | 0.141 | 0.016** |
| FD_NEG | 0.127 | 0.024** |
| GF_POS | 0.060 | 0.012** |
| GF_NEG | 0.068 | 0.028** |
| FDI_POS | 0.031 | 0.015** |
| FDI_NEG | -0.318 | 0.029** |
| TI_POS | 0.028 | 0.027** |
| TI_NEG | 0.041 | 0.096* |
| EG_POS | 0.183 | 0.007** |
| EG_NEG | -0.292 | 0.060** |

Notes: *,**, & *** indicates the level of significance at the 10%, 5%, and 1% respectively. Therefore, the symbol of POS and NEG evaluates the long-run effects of dependent variables. However, devised the negative coefficient of each variable positive for calculating the long-run coefficient and negative shock of the FD (-1) ($-\frac{\theta^+}{k}$ and $-\frac{\theta^-}{k}$) respectively.

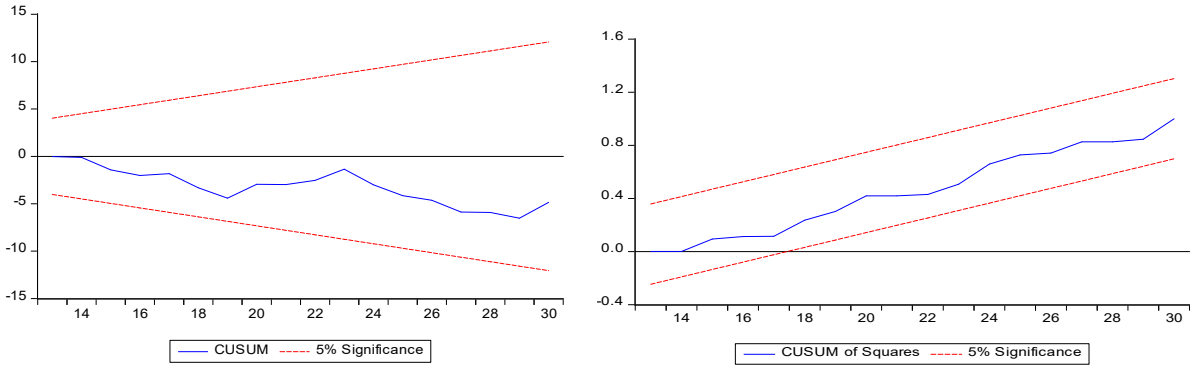
Furthermore, the TI_POS and TI_NEG are significant at 5% and 10% respectively and their coefficients are 0.028 and 0.041 which means there is an asymmetric relationship exists among the variables. This means a 1 unit increase in technology will lead to increases in the 0.028 unit of environmental sustainability. The efficiency of "technology innovation" enables the removal of polluted factors from the environment (Ellinghaus et al., 2020). Moreover, 4.0 technologies of environment utilized some tools which help to slow the process of $CO_2$emission. Therefore, (Zhao et al., 2020),showed that artificial intelligence helped to reduce $CO_2$ emission almost to save the 30% cost of environment sustainability. Furthermore, the negative shock of

environmental technology will increase the environment suitability and reduced the carbon emission as Table 6 reported the result of negative shock and it is significant which means 1 unit decreases in environmental technology will lead to reducing the carbon emission and has the inverse relationship. Furthermore, the EG_POS and EG_NEG have the coefficients 0.183 and -0.292 respectively and these variables are remarkable when level of significance is 5% which means it is confirmed that there is asymmetric relationship is exist. Furthermore, the EG_POS shows the 1% increase the renewable energy utilization will cause a rise of 0.183 % in environment sustainability in the long-run. Moreover, geothermal energy is the best option for the environment suitability and also reduces carbon emissions from the environment(Banales et al., 2020). However, the EG_NEG shock indicates the reduction of the carbon emission and also has the inverse association between the variable. This means 1% decrease in renewable energy will lead to reduce the 0.292 % of carbon emission because the treatment process requires lots of demand energy consumption and the lack of renewable energy will produce the carbon emission and this will pollute the environment.

**CUSUM and CUSUMSQ**

Brown et al. (1975) suggested using CUSUM and CUSUMSQ to check the model's data stability. Additionally, it holds true for the long-term stability of coefficients. Because the blue lines at a 5% level of significance lie between the upper and lower critical boundaries, the aforementioned figures demonstrate that the data are stable. This requirement demonstrates that the coefficients are stable

**Model stability test:**




**5.Conclusion and policy implication**

The present study analyzed the relationship between green finance, financial development, economic growth, foreign direct investment, and technology innovation on $CO_2$ emission in Pakistan. The study employed the asymmetric ARDL approach and used the yearly data for the period 1980 to 2021. Therefore, our outcomes showed the positive shock and negative shock of green finance and financial development have a significant relationship with $CO_2$ emission in long run. However, the positive change of FDI_POS has a significant and positive link with $CO_2$, Furthermore, the TI_POS and TI_NEG are significant and positive association with $CO_2$ emission at 5% and 10% respectively which means there is an asymmetric

relationship exists among the variables. The efficiency of "technology innovation" enables the removal of polluted factors from the environment. The study suggests to the researchers utilize the different measurement proxies for the environmental pollution and also recommended the researchers use these variables such as(innovation in renewable energy, and industrialization) for the other developing countries like Pakistan, India, and Bangladesh. This variation might be due to green finance market conditions (e.g., bearish or bullish) and country-specific market conditions. The findings in the study confirmed that green finance is the best financial strategy for reducing $CO_2$ emissions.

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