https://doi.org/10.52131/joe.2023.0502.0137

*i*RASD Journal of Economics

Volume 5, Number 2, 2023, Pages 422 – 440

Journal Home Page:
https://journals.internationalrasd.org/index.php/joe

Analyzing the Impact of Geopolitical Risk, and Renewable Energy Towards Sustainable Development in China

Fatima Farooq[1], Arsalan Tanveer[2], Muhammad Faheem[3]

[1] Associate Professor, School of Economics, Bahauddin Zakariya University, Multan, Pakistan. Email: fatimafarooq@bzu.edu.pk

[2] Scholar, School of Economics and Management, Nanjing University of Science and Technology, Nanjing, China 210094. Email: arsalantanveer1489@gmail.com

[3] Assistant Professor, School of Economics, Bahauddin Zakariya University, Multan. Pakistan. Email: faheem@bzu.edu.pk

ARTICLE INFO

Article History:

Received:	April	18, 2023
Revised:	June	27, 2023
Accepted:	June	28, 2023
Available Online:	June	29, 2023

Keywords:
Renewable Energy
Geopolitical Risk
Foreign Direct Investment
Economic Growth
NARDL

JEL Classification Codes:
J13, Q01

Funding:
This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ABSTRACT

Geopolitical relationship among the economies plays a crucial role in the environmental sustainability. In lieu our research reveals that whether geopolitical risk asymmetrically affects the reduction of carbon emission? To investigate this issue, we scrutinize the impact of geopolitical risk using annual data spanning 1990-2018 for China. Furthermore, our study employs nonlinear and liner autoregressive distributed lag simulations at the same time to argue the impact of geopolitical risk on environmental sustainability. Our empirical outcomes evidenced the asymmetric effect of geopolitical risk on the environment by indicating a positive association among geopolitical risk and environmental sustainability. Moreover, increasing foreign direct investment upsurges CO2 emanation which proves the pollution haven proposition. The results expressed a significant positive link of energy ingesting and GDP influence on CO2 emanation while renewable energy consumption reduces CO2 emission. Therefore, utmost attention must be taken to balance the environment and geopolitical risk. It is necessary to take initiatives to reforms policies that protect the environment without affecting geopolitical risk. Additionally, government officials and policymakers should articulate strategies to encourage renewable energy consumption as the energy combination outpouring to enrich the excellence of the environment. The findings also advocate that policymakers to welcome the environment-friendly foreign direct investment as it is the perpetrator to upsurge environmental degradation in China.

Corresponding Author's Email: faheem@bzu.edu.pk

Citation: Farooq, F., Tanveer, A., & Faheem, M. (2023). Analyzing the Impact of Geopolitical Risk, and Renewable Energy Towards Sustainable Development in China. *IRASD Journal of Economics*, *5*(2), 422–440. https://doi.org/10.52131/joe.2023.0502.0137

1. Introduction

Geopolitical risk asserts tremendous effects on the economy, trade cycle, energy resources management, and environmental sustainability. Freshly, Caldara and Iacoviello (2018) formulated an catalogue for examination of geopolitical risk (GR) and defined GR as "the risk connected with conflicts, battles, extremist acts, rigidities, and strains with reference to situations that affect the ordinary sequence of national political and international associations"

(Anser, Syed, & Apergis, 2021). Geopolitical risks are thought to distress financial markets, and business series with geopolitical risks most of the time cited by central bankers, business investors, and the financial press as one of the bases of investment decisions (Enamul Hoque, Soo Wah, & Azlan Shah Zaidi, 2019). Furthermore, geopolitical risk has social, political, and economic effects on the country. Additionally, in the previous year's several geopolitical risk events such as the 9/11 attack by terrorists in the United States of America, China, and the US business relations and trade war, Pakistan and India political pressures on Kashmir and Bombay attacks has changed the mindsets of the investors and business (Wang, Su, & Umar, 2021). At present International Monterey funds (IMF) and the World Bank highlighted many geopolitical risk issues in their reports (Alsagr & van Hemmen, 2021). Many authors focused on the effects of geopolitical risk in standings of economic growth, and cleaner energy solutions (Abdul, Wenqi, & Sameeroddin, 2023; Khan, Su, & Tao, 2021). Furthermore, geopolitical risk plays a crucial role in environmental sustainability.

Conforming to the National year book of China (China, 2020). China has gained a dramatic increase in the economic growth of averaged 7.2 percent in the year 2020 and retained the position of the world's second-largest economy (Worldometer, 2021). The intensification in economic progress causes environmental degradation but afterward a long period, the graph becomes inverted U shaped and the environment starts improving it is theorized as the environmental Kuznets curve (Kuznets, 1955). However, the enhanced economic development leads towards more fossil energy consumption (Oil, Gas, and Coal) in China that has increased from 3.10 percent in the year 1978 to 18.01 percent in the year 2018 badly pollutes the environment (China, 2020). So, it is a dilemma to sustain a balance between economic growth and environmental sustainability (Abdul, Wenqi, & Tanveer, 2022a; Tanveer, Song, Faheem, & Chaudhry, 2022). Non-renewable energy consumption asserts two-fold impacts on the economy, on the one hand, the imports of fossil energy consumption like oil, coal, etc. deposits a huge load on the economic progress of the country, and the other hand fossil energy consumption produces harmful discharges in the environment (Shafiq, ur Raheem, & Ahmed, 2020). The energy mix for China indicated that as compared to the year 2018 it has reduced the crude oil consumption by only 1 % percent in the year 2019. However, due to the COVID-19,the increase in natural gas is 6.9% in the year 2020, and coal consumption has a minor reduction of 1 percent in the year 2020 (China, 2020).

According to the British Petroleum Statistics Report 2020, the overall fossil energy consumption is increased by 2.1 percent (*British Petroleum Energy Statistical Review*, 2020). China is among the world's few economies that has increased the energy demand in the year 2020 (*World Bank Developmnet Indicators*, 2020). The increasing trend of the natural gas and continuous use of oil and coal for the energy needs produces greenhouse gases emission in China. From the previous 4 years, carbon emissions are rising by 0.6 percent (*British Petroleum Energy Statistical Review*, 2020). Moreover, China's global share for carbon dioxide emission enhanced to 31 % among the entire world (*British Petroleum Energy Statistical Review*, 2020). Carbon dioxide (CO_2) emissions badly pollute the environment and human health. The rise in carbon dioxide emission is caused due to many factors such as economic policy uncertainty, economic growth, FDI, fossil energy sources, geopolitical risk and many related factor (Farooq, Gillani, Subhani, & Shafiq, 2023).

In parallel to the above discussion, adopting renewable energy production has provided a vital solution for coping with environmental degradation and climate change vulnerability (Pata, 2021). Renewable energy (RE) development is as important for China and world economies to get cleaner environments (Wang, Zhang, Ji, & Shi, 2020). In the present time, several prior studies stressed the tremendous role of RE sources in the national energy blend for the economy (Abdul, Wenqi, & Tanveer, 2022b; Hassan et al., 2023; Tanveer, Anwer, & Umar, 2021). After the law passed for renewable energy on 28 February 2005 more subsidies and policies are formulated for cleaner energy productions. Furthermore, in the year 2020, China headed the world in addition to renewable energy foundations, comprised of about 45% (117 GW) of connections and practically expanding its own add-ons of the earlier year (China, 2020). It also persisted the worldwide spearhead in cumulative RE capacity (908 GW) at year's end, followed by the United States, Germany, Brazil, and India. China led global markets for concentrating solar thermal power, hydropower, solar PV and wind power (*British Petroleum Energy Statistical Review*, 2020; China, 2020). Furthermore, foreign direct investment is an important factor for environmental degradation mitigation (Zubair, Samad, & Dankumo, 2020). There are two directional concepts behind the FDI and CO_2 radiations. On the one hand, the established country strictly manages their environmental concerns and shifts their polluting productions towards the economies with weak environmental policies that prove the pollution halo hypothesis (Terzi & PATA, 2020). Conversely, several economies just focus on the economic growth by more and more FDI inflows and pollute the environment due to the less control on environmental policies validates the pollution haven concept (Doğan, Balsalobre-Lorente, & Nasir, 2020). However, FDI imparts cleaner technologies in some countries with improved technological plans with clean and green environment (Tanveer, Song, Faheem, Daud, & Naseer, 2021; Zhang & Zhang, 2018).

The present research engrossed on the dynamics of China for study due to the revealed appealing properties. Firstly, China sustains the biosphere's major population with the world's second-largest economy (Worldometer, 2021). Secondly, it is the world's largest oil importer and carbon emitter. Moreover, crude oil is the mainstay for the industrialization and economic growth of China (British Petroleum Energy Statistical Review, 2020). Thirdly, China is highly focused on renewable energy installation projects in the world and is in the leading position among the USA, Japan, Spain, Germany, the United Kingdom (UK) and France (China, 2020). Chronically, geopolitical risk is a highly discussed topic these days by researchers and policymakers. The previous studies regarding the geopolitical risk for China are highly focused on crude oil security, cash holdings, and financial constraints (Lee & Wang, 2021; Wang, Xiong, Mirza, Shao, & Yue, 2021). However, little contribution is grabbed for the possessions of geopolitical risk, energy usage (Non-renewable and Renewable energy), economic development, and FDI inflows regarding China (Yang, Wei, Li, & He, 2021).

The existing gap is estimated through econometric models in our research that adds to the research literature in various behaviors. Firstly, previous literature misleads by proving symmetric association but the current research estimated the asymmetric effects of geopolitical risk for carbon dioxide emissions. For this purpose, the study applied the updated methodology of Shin, Yu, and Greenwood-Nimmo (2014) for analyzing the negative and positive shocks of geopolitical risk. Secondly, the study examined the comparison of fossil energy ingesting and renewable energy usage for China. Thirdly, our work incorporated structural breaks through Zivot and Andrews (2002) during econometric analysis which is missing in previous literature. Fourthly, our study is supportive for government officials and bureaucrats for the formulation of procedures concerning geopolitical risk and environmental sustainability.

The paper further elaborated in the four sections. The second unit, minutiae about a transitory literature examination, the third sector mentioned the research method, along with econometric strategy, variables descriptions, the fourth section describes the results and analysis under a list of estimated tests, and the fifth section gives the concluding remarks with practical policies for government officials and policymakers.

2. Brief Literature Review

The critical review of the study sheds light on the variables under examination that is critically supported by the previous research. The present model of the research examined carbon emissions as dependent variables and exogenous variables are geopolitical risk, foreign direct investments inflows, energy consumption, renewable energy intake, and economic development.

2.1. Geopolitical Risk and Carbon Emissions

Geopolitical risk includes the factors like terrorism, wars, and political issues among economies that why geopolitical became a debatable concern these days Mohsin, Zhou, Iqbal, and Shah (2018) for South Asian countries, Garlick (2020) for China and Pakistan, K.-H. Wang, D.-P. Xiong, et al. (2021) in China, Khan et al. (2021) for Saudi Arabia, and Enamul Hoque et al. (2019) for Malaysia.

Anser et al. (2021) probed the effects of RE in comparison of non-renewable energy (NRE) usage, geopolitical risk factor on the carbon discharges for the (BRICS) Brazil, Russia, India, China, South African countries for the time 1985 to 2015. The conclusion supported that geopolitical risk and non-renewable energy feeding enhances environment deterioration in BRICS countries. K.-H. Wang, C.-W. Su, et al. (2021) articulated the reputation of geopolitical risk and oil security in the perspectives for China using mixed frequency to find the causal relationship. The results declared that China should maintain good relationships with the oil-exporting countries for the smooth working and getting crude oil needs. Furthermore, the scholarly work of K.-H. Wang, D.-P. Xiong, et al. (2021) asserts the inspiration of cash holding by crude oil-related firms and geopolitical risk for China. The findings are explained that oil exploration firms should have cash holdings to avoid geopolitical risk for getting crude oil in the future. Sweidan (2021) discussed the geopolitical risk with adoption of renewable energy productions for the United States of America using the autoregressive distributive lag (ARDL) co-integration analysis, under quarterly data from 1973 to 2020. The research of Sweidan (2021) aimed at grabbing the role geopolitical risk for the cleaner productions for the United States and findings determined that the US is the world's leading economy and is highly influenced by the geopolitical risk in achieving economic growth and renewable energy productions. Furthermore, geopolitical risk plays a backbone role in attaining renewable energies for a cleaner environment.

2.2. Energy Utilization and Carbon Emanations

Fossil energy intake in relationship with carbon productions remained the most debatable topic from the past two decades. Many researchers estimated the drawbacks and reduction policies for energy consumption in association with environmental sustainability (Ali, Gong, Ali, Wu, & Yao, 2021; Hanif, Nawaz, Hussain, & Bhatti, 2022; Nawaz, Ahmad, Hussain, & Bhatti, 2020; Tanveer, Anwer, et al., 2021). The exploration made by Wang, Li, Xu, and Zhang (2014) focused on the transportation (Railways, Air transport, Road vehicles, and Water transport) energy consumption for China. The finding showed that fossil energy consumption portrays bad effects on the environment in China.

The research scrutinized by Ahmad et al. (2016) asserted link amid CO_2discharges, economic development and energy consumption for India during 1971 to 2014 using times series data. The outcome determined a positively increasing linking between carbon radiations and fossil energy consumption (Bhatti, ur Raheem, & Zafar, 2020). Zakaria and Bibi (2019) explored the association of CO_2 emissions, energy utilization, and financial progress for the span of 1985 to 2015 for the South Asian countries examined the yearly data. The judgments evidenced the endorsement of an inverted U-shaped graph for energy consumption and square energy consumption with carbon dioxide emissions. Ahmad, Khan, Rahman, and Khan (2019) studied the link between carbon emissions and usage of energy for China for time series data from 1980 to 2014 and determined a positive association between carbon emissions and fossil energy use. Furthermore, many studies proclaimed that energy usage is the backbone for environmental deprivation like Tanveer, Song, Faheem, and Daud (2023) in Pakistan, Ahmad and Zhao (2018) among China, and Ahmad et al. (2016) for India.

2.3. Renewable Energy Sources and Carbon Emanations

The world economies are facing the issue of energy crises with environmental degradation. Renewable energy sources are the best alternatives for energy production in cleaner environments (Abdul et al., 2022a). In the present decade, RE sources and environmental sustainability become the most debatable topic for policymakers and researchers (Fazal, Gillani, Amjad, & Haider, 2020; Nawaz, Azam, & Bhatti, 2019; Pata, 2021; Ulucak & Khan, 2020).

Chien et al. (2021) asserted research on technological developments, RE sources, and globalization with environmental pollution for Pakistan under time-sequences since 1980 to 2018. The study estimated the quantile autoregressive distributive lag (QARDL) methodology and suggested that renewable energy sources (solar and wind) and technological innovations aid the environmental sustainability for each quintile. Nawab, Bhatti, and Nawaz (2021) found that technological innovations play an important role to keep environment healthy. Green energy is also plays a significant role in reducing emissions (Hussain, Nawaz, Ahmad, & Bhatti, 2021). Wang, Zhang, and Zhang (2021) focused on the renewable energy sources and financial development for China from 1997 to 2017. The research governed the ARDL-PMG model to get the long and short run grades. The conclusion advocates that economic progress pollutes the environment however, financial development and renewable energy clean the environment. Financial development leads China towards developing more renewable energy sources (Zhao & Luo, 2017). Farooq, Subhani, Shafiq, and Gillani (2023) found that environmental tax rate decrease the pollution emissions. Ulucak and Khan (2020) advocated the link of renewable energy, urbanization, and natural resources for cleaner environment for BRICS republics from 1992 to 2016. The outcome devised that renewable energy showed negative results with environmental pollution. There are many other researchers that proclaimed the negative linkage between renewable energy sources and better environmental conditions Ibrahiem (2020) in Egypt, and Naz et al. (2019) in Pakistan.

2.4. Foreign Direct Investments and Carbon Emissions

In some economies, foreign direct investments (FDI) inflow cleans the environment while for others it becomes a horrible factor for degrading the environment (Tanveer, Anwer, et al., 2021). FDI gives two-dimensional effects for the economies of the world. One dimension where FDI inflows clean the environment due to strict policies states the pollution halo hypothesis (PHH) and on the other side weak policies lead towards environmental degradation known as the pollution haven hypothesis (Ali et al., 2021). So, in spite of FDI that provides mixed results for economies of the world. Some studies proved a positive association between environment and FDI like Abbasi and Riaz (2016) in Pakistan, Zhang and Zhang (2018) in China, and Shahbaz, Balsalobre-Lorente, and Sinha (2019) in MENA states. Conversely, several authors validate the halo hypothesis and showed a negative link between FDI and the environment such as Ahmad, Khattak, Khan, and Rahman (2020) for G7 countries.

2.5. Economic Development and Carbon Emanations

The goal of the global economy is to achieve ever-increasing growth. But in the race for higher economic growth environmental sustainability is at stake (Gorus & Aydin, 2019). Many studies validated the positive association of economic growth and environmental pollution such as Ahmed and Wang (2019) among India, Rahman and Ahmad (2019) in Pakistan, Ahmad et al. (2020) for OECD nations, and Ibrahiem (2020) for Egypt.

The outcomes of Sarkodie and Strezov (2019) described greenhouse showed a positive connection with China, India, Iran, Indonesia, and South Africa. Ahmad et al. (2019) inspected economic and financial progress, with carbon discharges in China for the time span 1980 to 2014. The consequence showed with an upsurge in economic development environmental pollution increases to an advanced rate which is a global dilemma. Ali, Ashraf, Bashir, and Cui (2017) determined the relation of economic boost and carbon productions for the years 1960 to 1990 and found positive effects on the environmental dilapidation in the agriculture division of Pakistan.

The literature of the study motivated to work out the asymmetric special possessions of geopolitical risk under the umbrella of RE ingestion, FDI, economic development, and CO_2 emanations for the developing economy of China.

3. Research Data, Models and Methodology

To get valuable insights through the dynamics of long run and short run association amid the variables of the study, the present research examined the yearly data records from 1990 to 2018 for China. The carbon dioxide emanations (CO_2) work as the reliant on variable while geopolitical risk, energy consumption, renewable energy (RE) ingesting, foreign direct investments inflow (FDI) and economic development are estimated as the independent variables. The descriptions of the variables, signs and foundations are briefly mentioned in Table 1. Our research explored the symmetric and asymmetric effects of geopolitical risk with CO_2 emissions. Carbon emissions and geopolitical risk possess a strong relationship that is inspected in the previous research outcomes by (Meirun, Mihardjo, Haseeb, Khan, & Jermsittiparsert, 2021). Furthermore, many of the world economies import the energy needs from other countries, and FDI that's why geopolitical risk, energy consumption, economic growth, and FDI holds a strong association (Sweidan, 2021; Yang et al., 2021).

Table 1
Variable Details and Sources

Variable	Symbol	Details	Data Source
Carbon emission	CBE	CO_2 emanations (Metric tons per capita)	World Bank
Geopolitical Risk	GPR	Geopolitical Risk Index	Policyuncertainty.com
Energy Usage	ENC	Energy use (Per Kg of oil equivalence per capita)	World Bank
Renewable Energy Usage	RENR	Renewable energy usage (% of total final energy consumption)	British Petroleum
Foreign direct investments	FDIN	Foreign direct investment, net inflows (Bop, current US$)	World Bank
Gross Domestic Products	GDP	GDP (constant 2010 US$)	World Bank

3.1. Econometric Scheme

For the sake of analysis, several studies estimated different techniques to discover out the long term and short-run families among the analyzed variables. We employed econometric estimation of the autoregressive distributive lag technique (ARDL) for symmetric outcomes projected by Pesaran and JS (2001) to ascertain the influence of carbon emissions on geopolitical risk, RE and NRE utilization in the presence of economic development, and FDI. Furthermore, non-linear autoregressive distributive lag (NARDL) for analyzing asymmetric results by Shin et al. (2014) to determine the positive shockwaves and negative effects of geopolitical risk and carbon emissions.

The ARDL co-integration testing technique is quite feasible for our research to acquire the short and long run outcomes due to surprising benefits mentioned below. In first, the ARDL method is the finest one for the low data range and extent. Secondly, in the statistical perspectives, it is closely equivalent to the standard correction term (ECT) model. Third, the ARDL estimates co-integration among the variables through the bounding test criterion. The variable's stationary values must be of the mixed sequence of integration i.e. at level I (0), and I (1) but no value for second-order I (2). Fourthly, it gives the short with long run association for the data variables under discussion. Fifthly, it estimates the residual value in the form of an error correction term known as the ECT term (Banerjee, Dolado, & Mestre, 1998).

The NARDL procedure is the extended conception of the ARDL process offered via (Pesaran & JS, 2001). The NARDL method shows similar advantages with the ARDL estimation with asymmetric results. However, it is the appropriate methodology to examine the negative (GPR^-) and positive (GPR^+) shocks of geopolitical risk with carbon emanations. The differentiated benefits of the NARDL approach are mentioned. First, it captures the asymmetric non-linear association in a single equation that gives a better performance for the small sample. Second, it estimates the various lag values to validate the various models of the study. Additionally, ARDL and NARDL methods are more appropriate than conventional techniques of Granger and Johansen and Julius that is restricted to all the variables must be co-integrated at first order.

3.2. Mathematical Specifications of Model

The existing research investigated the impact of CO_2 emanations on independent variables i.e., geopolitical risk, NRE consumption, RE use, foreign direct investments inflow, and gross domestic product as a proxy of economic development mentioned in equation 1.

$$CBE = f(GPR, ENC, RENR, FDIN, GDP) \quad (1)$$

Where CBE represents the carbon dioxide emissions, GRP indicates the geopolitical risk, ENC shows the non-renewable energy consumption, RENR indicates renewable energy sources, FDIN asserts the foreign direct investments inflows, and GDP donates the gross domestic products.

$$CBE_t = \mu_1 + \mu_2 GPR_t + \mu_3 ENC_t + \mu_4 RENR_t + \mu_5 FDIN_t + \mu_6 GDP_t + \mu_t \quad (2)$$

The coefficients μ_2, μ_3, μ_4, μ_5, and μ_6 are the elasticity value of carbon dioxide emissions concerning geopolitical risk, fossil energy usage, renewable energy expenditure, foreign direct investment, financial development, and economic growth. The current research applied the ARDL and NARDL to get the symmetric and asymmetric outcomes that are employed by many researchers in previous studies (Faheem, Azali, Chin, & Mazlan, 2022; Tanveer et al., 2022).

$$\Delta CBE_t = \delta_0 + \sum_{i=1}^{l} \delta_{1i} \Delta CBE_{t-1} + \sum_{i=0}^{p} \delta_{2i} \Delta GPR_{t-i} + \sum_{i=0}^{q} \delta_{3i} \Delta ENC_{t-i} + \sum_{i=0}^{r} \delta_{4i} RENR_{t-i} + \sum_{i=0}^{s} \delta_{5i} \Delta FDIN_{t-i} + \sum_{i=0}^{\beta} \delta_{6i} \Delta GDP_{t-i} + \mu_1 CBE_{t-1} + \mu_2 GPR_{t-1} + \mu_3 ENC_{t-1} + \mu_4 RENR_{t-1} + \mu_5 FDIN_{t-1} + \mu_6 GDP_{t-1} + \mu_t \quad (3)$$

In the overhead mathematical equality, Δ expressed the first differences I (1) assessment for the applied variable and the resolute drift limit calculations δ_0. The unhindered error correction term (ECM) Banerjee et al. (1998) projected as in the below equation:

$$\Delta CBE_t = \delta_0 + \sum_{i=1}^{l} \delta_1 \Delta CBE_{2_{t-i}} + \sum_{i=0}^{p} \delta_2 \Delta GPR_{t-i} + \sum_{i=0}^{q} \delta_3 \Delta ENC_{t-i} + \sum_{i=0}^{r} \delta_4 \Delta RENR_{t-i} + \sum_{i=0}^{s} \delta_5 \Delta FDIN_{t-i} + + \sum_{i=0}^{\beta} \delta_{6i} \Delta GDP_{t-i} + \lambda ECT - 1 + v \quad (4)$$

In the upper math model, λ expresses the rapidity of regulating parameter with the error correction stretch (ECT) that designates the enduring values from the analyzed math design. Furthermore, the non-linear equation is projected that demonstrates asymmetric effects of geopolitical risk according to the NARDL technique where geopolitical risk is split into positive and negative forms.

$$CBE_t = \mu_1 + \mu_2^{+} GPR^{+}_t + \mu_2^{-} GPR_t^{-} + \mu_3 X_t + \varphi_t \quad (5)$$

Constructed on the non-linear math Equation (5), μ_2^+shows geopolitical risk influence on carbon release in long term in equation (6), that is predictable to be positive. Where, μ_2^- in the math equation (7) designates the reducing impact among CO_2 emission and geopolitical risk.

$$\mu_2^{+} GPR_t^{+} = \sum_{j=1}^{t} \Delta GPR_j^{+} = \sum_{j=1}^{t} \max(\Delta GPR_j, 0) \quad (6)$$

$$\mu_2^{-} GPR_t^{-} = \sum_{j=1}^{t} \Delta GPR_j^{-} = \sum_{j=1}^{t} \max(\Delta GPR_j, 0) \quad (7)$$

Math equation (8) focuses on the positive shockwaves and negative shockwaves of geopolitical risk on the carbon emanations for China. The long-term and short-term asymmetry is restrained by μ_2^+andμ_2^-, δ_2^+ and δ_2^- separately by the below-given hypotheses:

$$\Delta CBE_t = \delta_0 + \sum_{i=1}^{l} \delta_{1i} \Delta CBE_{2t-1} + \sum_{i=0}^{p1} \delta^{+}_{2i} \Delta GPR^{+}_{t-i} + \sum_{i=0}^{p2} \delta^{-}_{2i} \Delta GPR^{-}_{t-i} + \sum_{i=0}^{q} \delta_{3i} \Delta ENC_{t-i} + \sum_{i=0}^{r} \delta_{4i} \Delta RENR_{t-i} + \sum_{i=0}^{s} \delta_{5i} \Delta FDIN_{t-i} + \sum_{i=0}^{s} \delta_{6i} \Delta GDP_{t-i} + \mu_1 CBE_{t-1} + \mu_2^{+} GPR_{t-1}^{+} + \mu^{-}_2 GPR^{-}_{t-1} + \mu_3 ENC_{t-1} + \mu_4 RENR_{t-1} + \mu_5 FDIN_{t-1} + \mu_5 GDP_{t-1} + \phi_t \quad (8)$$

H0: $\mu_2^+ = \mu_2^- = 0$

$$H_0: \sum_{i=0}^{p1} \delta^{+}_{2i} = \sum_{i=0}^{p2} \delta^{-}_{2i}$$

For the entire values i =0… p.

4. Empirical Analysis

The research analysis is supported out by the autoregressive distributive lag (ARDL) model for the symmetric outcomes and the NARDL operations for the evaluation of asymmetries results of geopolitical risk with carbon discharges for China during the period 1990 to 2018. The research examined the impact of carbon radiations on geopolitical risk, non-renewable energy, renewable energy, FDI and GDP.

4.1. Description Statistical Analysis

The description statistics of the exogenous and endogenous variables has been designated Table 2 which is based on the median, mean, maximum, probability, minimum, and standard deviation math statistics.

The descriptive statistics mean, median, maximum, and minimum values are maximum for GDP and lowest for carbon emissions. Furthermore, the correlation matrix shows association among the variable. The correlation matrix indicates that carbon emissions and geopolitical risk are positively correlated, fossil energy consumption is positively correlated with carbon emissions and geopolitical risk, RE is negatively correlated with carbon emission, while GDP and FDI represent a positively relationship with CO_2.

Table 2
Descriptive Statistics

	CBE	GPR	ENC	RENR	FDIN	GDP
Mean	1.3760	4.3120	7.1783	2.9907	25.0020	28.8167
Median	1.3741	4.2138	7.1453	3.0037	24.9445	28.7934
Std. Dev.	0.4940	0.5001	0.4455	0.4270	1.18248	0.7941
Skewness	0.0137	0.2350	0.1626	-0.0635	-0.9153	-0.0919
Kurtosis	1.3636	2.2070	1.4006	1.2347	3.4239	1.7717
Maximum	2.0021	5.3153	7.8415	3.5288	26.3963	30.0173
Minimum	0.6494	3.5006	6.6023	2.4281	21.9723	27.4421
Probability	0.1982	0.5984	0.1999	0.1507	0.1184	0.3937
Jarque-Bera	3.2362	1.0267	3.2188	3.7848	4.2668	1.8638
Sum	39.9061	125.0504	208.1735	86.7306	725.0584	835.6870
Sum Sq. Dev.	6.8338	7.0054	5.5573	5.1074	39.1516	17.6562
Observations	29	29	29	29	29	29
CBE	**1**					
GPR	0.4180	**1**				
ENC	0.9944	0.4443	**1**			
RENR	-0.9915	-0.3691	-0.9825	**1**		
FDIN	0.9188	0.2634	0.8872	-0.8933	**1**	
GDP	0.9811	0.4704	0.9789	-0.9511	0.9315	**1**

4.2. Unit Root

The first step to start with the ARDL approach is finding the stationary analytics of the examined variables. For the evaluation of the unit root test the (ADF) Augmented Dickey-Fuller with (PP) Philips Peron tests are applied. The thumb of rule for the unit root states that the variables must be stationary at the level I (0), and the first difference I (1) with no second degree I (2) stationary value. The co-integration of the variables may be consisting of the mixed order of integration. The unit root test values for the current analysis seems white sound with all the variables i.e., CBE, GPR, ENC, RENR, FDIN, GDP expressed stationary figures at the first difference in Table 3. Further, structural breaks analysis with break year are presented in the Table 3 by estimating the Zivot & Andrews test.

Table 3
Unit Root Examination & Structural Year Breaks

Variable	At Level				At First difference				Decision
	ADF	PP	ZA	Year	ADF	PP	ZA	Year	
CBE	-0.337	-0.178	-4.096	2009	-3.328**	-3.280**	-4.114**	2012	I (1)
GPR	-2.537	-1.830	-4.385	2007	-5.353*	-4.932*	-10.147***	2004	I (1)
ENC	-0.029	0.464	-3.420	1996	-2.850**	-2.907**	-4.234**	2003	I (1)
RENR	-1.180	0.464	-3.688	2003	-2.859*	-2.907*	-4.972***	2003	I (1)
FDIN	-0.676	-0.649	-2.991	2010	-5.479**	-5.479**	-5.872***	2012	I (1)
GDP	-0.697	-1.054	-3.420	2001	-2.615*	-2.9113*	-5.094***	2011	I (1)

Note: *, **, ****, and **** for 10%, 5%, 2.5% and 1 % respectively.

4.3. F-Bounds Test (ARDL)

The second step for the ARDL system is the validation of the bound test approach. The long run integration among the affiliation of the variables is verified through the f-bound test. The f-bound statistic figure must be at greater level than the lower critical bound (LCB) and upper critical bound (UCB) value. The findings of the bounds test in Table 4 indicate that the f-statistic value (14.938) is greater than upper statistics with lower critics bound statistical values. The outcome validates the goodness of fit for the studied econometric approach.

Table 4
Bounds test assessments: (ARDL)

F-bound Examination		Null hypotheses: Not at the level relations		
		Significance	**I(0) Bound.**	**I(1) Bound.**
F-statistical	14.938	10%	2.45	3.52
K	4	5%	2.86	4.01
		2.5%	3.25	4.49
		1%	3.74	5.06

4.4. Long and Short Run Dynamical Estimates (ARDL)

The co-integration by limits test approves the existence of a long-term connection between the variables in question. Using the variables in the supplementary Table 5, the ARDL method manages the symmetric (linear) relationships of the variables and elucidates the dynamics of long and short run values. The long and short run outcomes indicated a significant positive link of carbon emissions with geopolitical risk. The discoveries are similar with Anser et al. (2021) for BRICS realms, and Al-Nuaimi, Banawi, and Al-Ghamdi (2019) for Qatar that suggesting that geopolitical risk plays a key role for the cleaner sources in the economies. The economies with good relationships can share cleaner environment ideas and technologies while the aims of wars, and terrorism badly move the economies towards environmental pollution. Especially, China is highly aimed towards good relationships with the world economies and highly inclined for a green environment.

Non-renewable energy (Gas, Coal, and Oil) resolute a positive with significant correlation with carbon productions in terms of short and long connection that is similar to the studies of Tanveer et al. (2022) for Pakistan, and Ahmad et al. (2019) in China. Basically, Pakistan, China, Turkey is related to the same geographical location and badly affected by fossil energy consumption especially due to fossil petroleum intake in the manufacture sector. However, China along with other world economies are highly concerned about reduction policies for fossil energy resources. Surprisingly, RE foundations (Solar, Wind) expressed a negative link with carbon emanations in the short and long run for China that supports the previous studies of Liu, Ren, Cheng, and Wang (2020) for G7 countries, and Rahman and Ahmad (2019) among Pakistan. The findings suggest that while renewable energy sources have long-term economic, social, and environmental benefits, they require an initial investment. In the year 2020, China became the world's largest country with renewable energy installations (China, 2020). Furthermore, Pakistan and other world countries are highly aimed towards the electrical vehicles, solar energy, and wind power projects to get the cleaner productions and environment.

Moreover, the findings of FDI significantly proved the pollution haven theory (PHH) in long and short run for China by validating a positive connection between carbon emissions and FDI. The outcome is similar to the previous studies like Abbasi and Riaz (2016) in Pakistan, Zhang and Zhang (2018) among China, and Ali et al. (2021) for Malaysia. The findings ascertain that FDI inflows badly pollute the environment deterioration however, enhances the economic development in the country. In this way many of the world economies pollute the environment at the rate of environmental degradation.

However, some economies proved the negative relationship of FDI and CO_2 emanations by confirmative the pollution halo hypothesis like Zakaria and Bibi (2019) for Asian economies, and Ahmed, Zafar, and Ali (2020) for G7 countries. In fact, the pollution halo hypothesis holds in the countries with strict environmental policies that only permit pollution-free inflows in their countries. For the economic growth that provided insignificant positive consequences in short terms and long run for carbon emissions in China. The consequences same to the previous contributions of Tanveer, Song, et al. (2021) in Pakistan, and Charfeddine and Kahia (2019) among MENA states. The findings explain that economic growing causes more fossil energy ingesting and manufacturing activities in the country that badly destroy the environment. Another way to verify the long run dynamics amongst the variables of the study is the error correction term (ECT) criterion. It is determined that the ECT term bears a negative sign with the significant coefficient value (Pesaran & JS, 2001). The ECT term for the current estimated model seems up to the standard.

Table 5
Long & Short Run Evaluations (ARDL Approach)

Long Run				
Variable	**Coefficients**	**Stdn. Error**	**t-Statistics**	**Prob**
GPR	0.0471***	0.0122	3.8339	0.0016
ENC	0.5724***	0.0590	9.7025	0.0000
RENR	-0.4209***	0.0339	-12.3858	0.0000
FDIN	0.0836***	0.0141	5.8932	0.0000
GDP	-0.0526	0.0381	-1.3824	0.1871
CONSTANT	-2.2307***	0.4926	-4.5281	0.0004
Short-run				
Variable	**Coefficient**	**Stdn. Error**	**t-Statistics**	**Prob**
D(GPR)	0.0340***	0.0088	3.8386	0.0016
D(GPR(-1))	-0.0246**	0.0087	-2.8379	0.0125
D(ENC)	0.3929***	0.1137	3.4548	0.0035
D(RENR(-1))	-0.4911***	0.0464	-10.5769	0.0000
D(FDIN)	0.0486***	0.0156	3.1061	0.0072
D(FDIN(-1))	-0.0214	0.0123	-1.7405	0.1022
D(GDP)	0.3424	0.2274	1.5057	0.1529
D(GDP(-1))	-0.4727**	0.2396	-1.9730	0.0672
ECT	-1.1667***	0.0916	-12.7329	0.0000

Note: *, **, ****, and **** for 10%, 5%, 2.5% and 1 % respectively.

4.5. Diagnostic Stability

The diagnostic estimates are conducted through various stability criterions like the Serial-lag range multiplier (LM) test, Durbin-Watson (DW) trial, Histogram normality trial, normality statistics by Jarque-Bera (JB), Hetero trial, Ramsey reset test, R-square and adjusted R-square in Table 6. The articulated values for the R-square is *0.999*, Durbin-Watson *2.443,* adjusted R-square *0.999*, J.B test *0.789,* Ramsey reset test *0.213,* and Hetero test value is 0.213. All the values in the diagnostic test seem white sound and lie in the acceptable region.

Table 6
Diagnostic Estimations (ARDL)

Diagnostic tests	**Statistics**
R^2	0.999
Adj R^2	0.999
Durbin Watson Stat	2.443 (0.000)
LM test	1.894 (0.189)
J.B test	0.789 (0.673)
Hetro test	0.637 (0.789)
Ramsey reset test	0.213 (0.834)

4.6. Non-Linear ARDL Estimates

Shin et al. (2014) use NARDL operations to evaluate the dynamics of expected unequal outcomes. The purpose of our study was to identify the dynamical impacts, both positive and negative, of geopolitical risk on carbon releases. Narayan and Smyth (2005) provided upper and lower critical bound standards to verify the long-term co-integration among the variables, and the calculated f-statistic value shown in Table 7 is greater than both. Furthermore, the Wald test is used to confirm the validity of long- and short-term asymmetry association in the NARDL. Table 7 shows the results of a Wald test, which confirms that there is a significant difference between the short- and long-term results.

Table 7
F-Bounds Estimates and Wald Test (N-ARDL)

		Null hypotheses: Not at level relations		
		Significance.	**I (0) Bound**	**I (1) Bound**
F statistics	11.0555	10%	2.75	3.79
K	5	5%	3.12	4.25
		2.5%	3.49	4.67
		1%	3.93	5.23
NARDL Wald Estimates				
Test	**F-statistics**	**Probability**	**Conclusion**	
W_{LR}	2.884	0.0124	Long Track asymmetric linkage occurs	
W_{SR}	0.671	0.04231	Short Track asymmetric linkage occurs	

4.6.1. Short and Long Run Analysis (NARDL)

Our research explored the asymmetric association of geopolitical risk (GPR^+ and GPR^-) with carbon dioxide emanations and presented in Table 8. The findings for the positive shocks of geopolitical risk (GPR^+) determined a significant positive result in short and long path. While the consequences for the negative effects of geopolitical risk (GPR^-) determined positive and insignificant result that validates the asymmetrical association of geopolitical risk and CO_2 emanations for China. The results show how both rising and falling geopolitical risk negatively affect ecosystems. There is also an adverse effect on the economy and the environment from terrorism, trade disputes, border concerns, political risk, and conflicts. The consequences like with Anser et al. (2021) for BRICS states. The findings revealed that geopolitical risk significantly enhances carbon emissions due to some tremendous factors. Firstly, GPR creates hindrance in the way of renewable energy sources, innovations, economic growths. Secondly, foreign direct investments inflows (FDI) is most of the time discouraged due to the geopolitical risk factors that ultimately escalates the carbon emissions. Thirdly, policymakers and government personnel deviate from environmental concerns under the geopolitical risk pressures in the economies.

Table 8
Short and Long Period Evaluations (NARDL)

Long Run Results				
Variable.	***Coefficients***	***Stdn. Error***	***t-Statistics***	***Prob.***
GPR^+	*0.0150***	*0.0076*	*1.9830*	*0.0613*
GPR^-	*0.0040*	*0.0156*	*0.2581*	*0.7989*
ENC	*0.5110****	*0.0852*	*5.9964*	*0.0000*
RENR	*-0.4201****	*0.0570*	*-7.3620*	*0.0000*
FDIN	*0.0442****	*0.0095*	*4.6298*	*0.0002*
GDP	*0.0298*	*0.0488*	*0.6099*	*0.5487*
C	*-3.0340*	*0.6548*	*-4.6332*	*0.0002*
Short Run Results				
Variable.	***Coefficients***	***Stdn. Error***	***t-Statistics***	***Prob.***
D(GPR^+)	*0.0170***	*0.0081*	*2.0837*	*0.0502*
D(GPR^-)	*0.0045*	*0.0177*	*0.2574*	*0.7994*
D(ENC)	*0.5778****	*0.1100*	*5.2527*	*0.0000*
D(RENR)	*-0.4751****	*0.0697*	*-6.8113*	*0.0000*
D(FDIN)	*0.0292***	*0.0125*	*2.3196*	*0.0311*
D(GDP)	*0.0337*	*0.0557*	*0.6054*	*0.5517*
ECT	*-1.1308****	*0.0807*	*-14.0072*	*0.0000*

Note: *, **, ****, and **** for 10%, 5%, 2.5% and 1 % respectively.

Concerning fossil energy use and renewable energy ingesting that presented significant positive and negative outcomes respectively in short-term and long run under the NARDL estimates. The outcomes are same as Le, Le, and Taghizadeh-Hesary (2020) for Asian countries. FDI indicated the same findings with ARDL i.e., significant positive effects with carbon emanations in short and long run. The outcome is the same as Tanveer, Anwer, et al. (2021) in Pakistan, while Ali et al. (2021) for Malaysia which stress that FDI inflows improve economic growth while badly affecting environmental pollution. The key issue is that FDI inflow causes more fossil energy consumption that result in environmental degradation. Further, concerning with economic growth revealed significant positive results in short and long terms that is in line with Zaidi, Hussain, and Zaman (2021) for OECD economies. In the end of Table 8 an alternative criterion for validation of long run co-integration showed significant and negative coefficient values.

4.6.2. Diagnostic Test

The R-square values 0.999, modified R-square values 0.999, serial LM test for normality 1.781, Jarque-Bera test 1.129, Hetero estimate 1.547, and Ramesy reset test 0.763 are used to validate the diagnostic analysis stability of the NARDL model. Table 9 displays the diagnostic stability results. This demonstrated that all of the values are inside the permitted range.

Table 9
Diagnostics Statistical Tests (NARDL)

Diagnostic Estimate.	*Statistics.*
.R^2	*0.999*
Adj. R^2	*0.999*
LM test	*1.781 (0.196)*
Jarque-Bera Analysis	*1.129 (0.568)*
Hetrodest test	*1.547 (0.203)*
Ramsey-Rreset test	*0.763 (0.454)*

4.6.3. Stability of Models

Figures 1 and 2 display cumulative sum graphical view and cumulative sum of square graphs, respectively, for ARDL models in order to demonstrate their stability. In addition, the cumulative sum and cumulative sum of square graphs for the asymmetric models are depicted in figures 3 and 4, respectively. The graphs are all at a good, steady spot. Figure 5 shows a multiplier graph, which further confirms the durability of the obtained asymmetric findings.

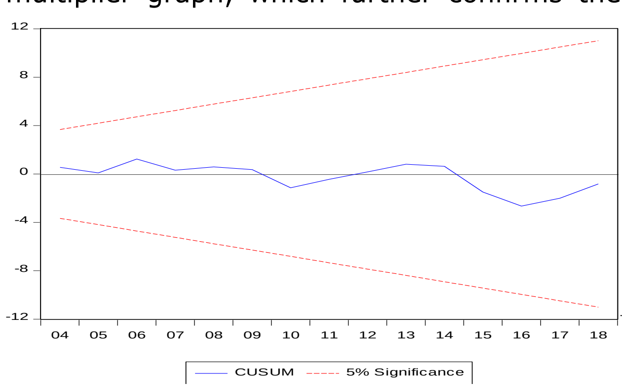

Figure 1: CUSUM (ARDL)

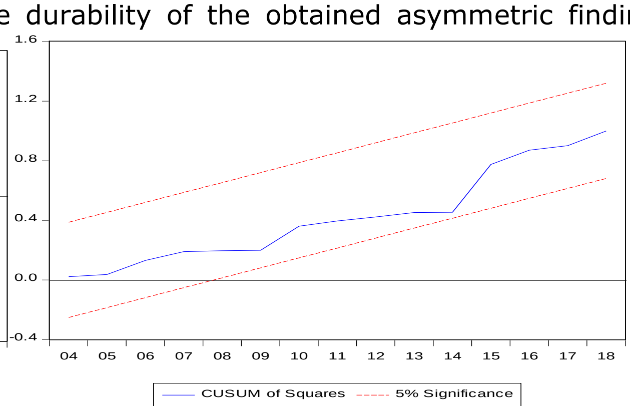

Figure 2: CUSUM(SQ) (ARDL)

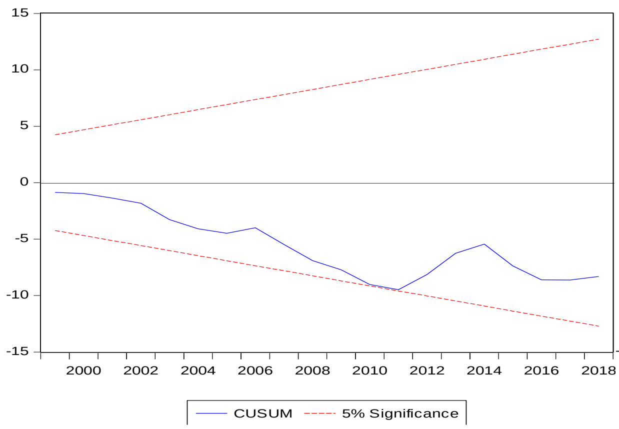

Figure 3: CUSUM (NARDL)

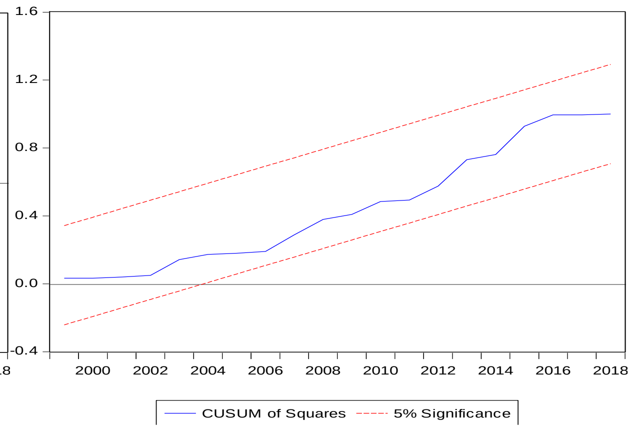

Figure 4: CUSUM(SQ) (NARDL)

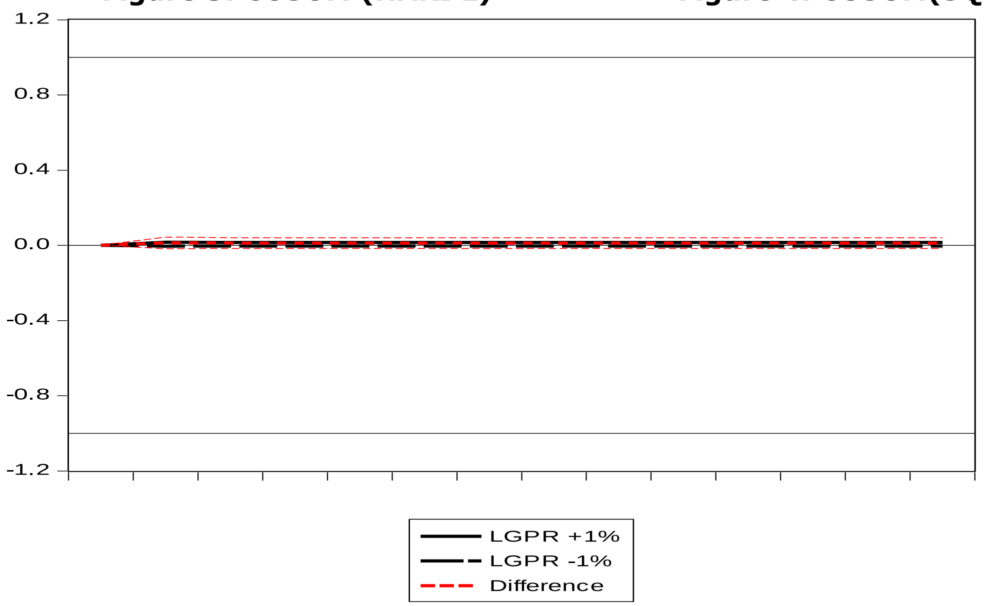

Figure 5: Multiplier Graph

5. Conclusion

This study calculates China's CO_2 under the asymmetric effect of geopolitical risk over 1990 to 2018. To achieve the objective, the study hires linear and nonlinear autoregressive distributed lag simulations at the same time to deliberate the impact of geopolitical risk in terms of asymmetry. Our paper also discusses the other factors like non-renewable and renewable energy consumption, real GDP including foreign direct investments to test the pollution haven hypothesis whether exists or not in China. The study's main conclusions are as follows:

The geopolitical risk for the country is a much more crucial factor that would affect the environment. To plug the existing cavity in prior literature our study results challenge the previous symmetric relation of geopolitical risk with the environment performance. Our empirical consequences revealed the asymmetric effect of geopolitical risk on the environment. The positive and negative change in geopolitical risk affects the environment differently. Further, geopolitical risk showed a significant positive linkage with environmental sustainability in China. The outcomes suggest that China should maintain good relationships with the oil rich countries to fulfill their energy needs. In parallel foreign direct investment (FDI) indicated positive linkage with environmental performance. Moreover, increasing FDI increases CO_2 emission which evidences the authentication of the pollution haven hypothesis. Adopting pollution-free foreign investment that reduces emission is one way for the Chinese economy to adapt its FDI structure.

According to the findings, using renewable energy sources instead of fossil fuel has a negative conclusion on CO2 emissions but increasing GDP does. To minimize carbon dioxide emissions in China, renewable energy consumption must be balanced with other environmental factors. Reforming environmental protection regulations without increasing geopolitical instability requires action. As the energy blend should be pouring out to create a cleaner, higher-quality atmosphere, the findings also indicate that government authorities and lawmakers create legislation to boost renewable energy consumption. Given its role in accelerating environmental deprivation in China, the study's conclusions also urge governments to welcome environmentally benign foreign direct investment.

Authors Contribution
Fatima Farooq: introduction, literature search, data collection
Arsalan Tanveer: study design and concept, writing-original draft
Muhammad Faheem: help in data analysis, data interpretation

Conflict of Interests/Disclosures
The authors declared no potential conflicts of interest w.r.t the research, authorship and/or publication of this article.

REFERENCES

Abbasi, F., & Riaz, K. (2016). CO2 emissions and financial development in an emerging economy: an augmented VAR approach. *Energy policy, 90*(3), 102-114. doi:https://doi.org/10.1016/j.enpol.2015.12.017

Abdul, D., Wenqi, J., & Sameeroddin, M. (2023). Prioritization of ecopreneurship barriers overcoming renewable energy technologies promotion: A comparative analysis of novel spherical fuzzy and Pythagorean fuzzy AHP approach. *Technological Forecasting and Social Change, 186*(1), 122133. doi:https://doi.org/10.1016/j.techfore.2022.122133

Abdul, D., Wenqi, J., & Tanveer, A. (2022a). Environmental stewardship: Analyzing the dynamic impact of renewable energy, foreign remittances, and globalization index on China's CO2 emissions. *Renewable Energy, 201*(12), 418-425. doi:https://doi.org/10.1016/j.renene.2022.10.113

Abdul, D., Wenqi, J., & Tanveer, A. (2022b). Prioritization of renewable energy source for electricity generation through AHP-VIKOR integrated methodology. *Renewable Energy, 184*(1), 1018-1032. doi:https://doi.org/10.1016/j.renene.2021.10.082

Ahmad, A., Zhao, Y., Shahbaz, M., Bano, S., Zhang, Z., Wang, S., & Liu, Y. (2016). Carbon emissions, energy consumption and economic growth: An aggregate and disaggregate analysis of the Indian economy. *Energy policy, 96*(9), 131-143. doi:https://doi.org/10.1016/j.enpol.2016.05.032

Ahmad, M., Khan, Z., Rahman, Z. U., & Khan, S. (2019). Does financial development asymmetrically affect CO2 emissions in China? An application of the nonlinear autoregressive distributed lag (NARDL) model *CARBON MANAGEMENT, 9*(6), 631-644.

Ahmad, M., Khattak, S. I., Khan, A., & Rahman, Z. U. (2020). Innovation, foreign direct investment (FDI), and the energy–pollution–growth nexus in OECD region: a simultaneous equation modeling approach. *Environmental and Ecological Statistics, 27*(2), 203-232. doi:https://doi.org/10.1007/s10651-020-00442-8

Ahmad, M., & Zhao, Z.-Y. (2018). Empirics on linkages among industrialization, urbanization, energy consumption, CO2 emissions and economic growth: a heterogeneous panel study of China. *Environmental Science and Pollution Research, 25*(30), 30617-30632. doi:https://doi.org/10.1007/s11356-018-3054-3

Ahmed, Z., & Wang, Z. (2019). Investigating the impact of human capital on the ecological footprint in India: an empirical analysis. *Environmental Science and Pollution Research, 26*, 26782-26796. doi:https://doi.org/10.1007/s11356-019-05911-7

Ahmed, Z., Zafar, M. W., & Ali, S. (2020). Linking urbanization, human capital, and the ecological footprint in G7 countries: an empirical analysis. *Sustainable Cities and Society, 55*(4), 102064. doi:https://doi.org/10.1016/j.scs.2020.102064

Al-Nuaimi, S., Banawi, A.-A. A., & Al-Ghamdi, S. G. (2019). Environmental and economic life cycle analysis of primary construction materials sourcing under geopolitical uncertainties: A case study of Qatar. *Sustainability, 11*(21), . doi:https://doi.org/10.3390/su11216000

Ali, G., Ashraf, A., Bashir, M. K., & Cui, S. (2017). Exploring environmental Kuznets curve (EKC) in relation to green revolution: a case study of Pakistan. *Environmental Science & Policy, 77*(11), 166-171. doi:https://doi.org/10.1016/j.envsci.2017.08.019

Ali, M. U., Gong, Z., Ali, M. U., Wu, X., & Yao, C. (2021). Fossil energy consumption, economic development, inward FDI impact on CO2 emissions in Pakistan: testing EKC hypothesis through ARDL model. *International Journal of Finance & Economics, 26*(3), 3210-3221. doi:https://doi.org/10.1002/ijfe.1958

Alsagr, N., & van Hemmen, S. (2021). The impact of financial development and geopolitical risk on renewable energy consumption: evidence from emerging markets. *Environmental Science and Pollution Research, 28*(20), 25906-25919. doi:https://doi.org/10.1007/s11356-021-12447-2

Anser, M. K., Syed, Q. R., & Apergis, N. (2021). Does geopolitical risk escalate CO2 emissions? Evidence from the BRICS countries. *Environmental Science and Pollution Research, 28*(35), 48011-48021. doi:https://doi.org/10.1007/s11356-021-14032-z

Banerjee, A., Dolado, J., & Mestre, R. (1998). Error-correction mechanism tests for cointegration in a single-equation framework. *Journal of time series analysis, 19*(3), 267-283. doi:https://doi.org/10.1111/1467-9892.00091

Bhatti, M. A., ur Raheem, F., & Zafar, M. A. (2020). Environmental Kuznets Curve (EKC): Empirically Examined Long Run Association Between Globalization, Financial Development and CO2 Emission for ASEAN Countries. *iRASD Journal of Energy & Environment, 1*(1), 01-13. doi:https://doi.org/10.52131/jee.2020.0101.0001

British Petroleum Energy Statistical Review. (2020). Retrieved from https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html

Caldara, D., & Iacoviello, M. (2018). Measuring geopolitical risk.[pdf] boston: Division of international finance. *Available at:< www2. bc. edu/matteo-iacoviello/gpr_files/GPR_PAPER. pdf>[Accessed 24 February 2018]*.

Charfeddine, L., & Kahia, M. (2019). Impact of renewable energy consumption and financial development on CO2 emissions and economic growth in the MENA region: a panel vector autoregressive (PVAR) analysis. *Renewable Energy, 139*(8), 198-213. doi:https://doi.org/10.1016/j.renene.2019.01.010

Chien, F., Ajaz, T., Andlib, Z., Chau, K. Y., Ahmad, P., & Sharif, A. (2021). The role of technology innovation, renewable energy and globalization in reducing environmental degradation in Pakistan: a step towards sustainable environment. *Renewable Energy, 177*(11), 308-317. doi:https://doi.org/10.1016/j.renene.2021.05.101

China, N. (2020). National Bureau of Statistics of China Webiste. In.

Doğan, B., Balsalobre-Lorente, D., & Nasir, M. A. (2020). European commitment to COP21 and the role of energy consumption, FDI, trade and economic complexity in sustaining economic growth. *Journal of environmental Management, 273*(11), 111146. doi:https://doi.org/10.1016/j.jenvman.2020.111146

Enamul Hoque, M., Soo Wah, L., & Azlan Shah Zaidi, M. (2019). Oil price shocks, global economic policy uncertainty, geopolitical risk, and stock price in Malaysia: Factor augmented VAR approach. *Economic research-Ekonomska istraživanja, 32*(1), 3701-3733. doi:https://doi.org/10.1080/1331677X.2019.1675078

Faheem, M., Azali, M., Chin, L., & Mazlan, N. S. (2022). Does oil price spur public expenditures in Saudi Arabia, Kuwait and United Arab Emirates? *Journal of Public Affairs, 22*(4), e2604. doi:https://doi.org/10.1002/pa.2604

Farooq, U., Gillani, S., Subhani, B. H., & Shafiq, M. N. (2023). Economic policy uncertainty and environmental degradation: the moderating role of political stability. *Environmental*

Science and Pollution Research, 30(7), 18785-18797. doi:https://doi.org/10.1007/s11356-022-23479-7
Farooq, U., Subhani, B. H., Shafiq, M. N., & Gillani, S. (2023). Assessing the environmental impacts of environmental tax rate and corporate statutory tax rate: Empirical evidence from industry-intensive economies. *Energy Reports, 9*(12), 6241-6250. doi:https://doi.org/10.1016/j.egyr.2023.05.254
Fazal, S., Gillani, S., Amjad, M., & Haider, Z. (2020). Impacts of the Renewable-Energy Consumptions on Thailand's Economic Development: Evidence from Cointegration Test. *Pakistan Journal of Humanities and Social Sciences, 8*(2), 57-67. doi:https://doi.org/10.52131/pjhss.2020.0802.0103
Garlick, J. (2020). Deconstructing the China-Pakistan economic corridor: Pipe dreams versus geopolitical realities. In *China's New Global Strategy* (pp. 191-205): Routledge.
Gorus, M. S., & Aydin, M. (2019). The relationship between energy consumption, economic growth, and CO2 emission in MENA countries: Causality analysis in the frequency domain. *Energy, 168*(2), 815-822. doi:https://doi.org/10.1016/j.energy.2018.11.139
Hanif, S., Nawaz, A., Hussain, A., & Bhatti, M. A. (2022). Linking non renewable energy, renewable energy, globalization and CO2 emission under EKC hypothesis: evidence from ASEAN-6 countries through advance panel estimation. *Pakistan Journal of Humanities and Social Sciences, 10*(1), 391–402-391–402. doi:https://doi.org/10.52131/pjhss.2022.1001.0204
Hassan, T., Khan, Y., Safi, A., Chaolin, H., Khan, S., Daud, A., & Tufail, M. (2023). Green financing strategy for low-carbon economy: The role of high-technology imports and institutional strengths in China. *Journal of Cleaner Production, 415*(8), 137859. doi:https://doi.org/10.1016/j.jclepro.2023.137859
Hussain, M. S., Nawaz, M. A., Ahmad, T. I., & Bhatti, M. A. (2021). Environmental governance and green energy: An administrative toolkit to reduce environmental degradation. *iRASD Journal of Management, 3*(3), 329-338. doi:https://doi.org/10.52131/jom.2021.0303.0049
Ibrahiem, D. M. (2020). Do technological innovations and financial development improve environmental quality in Egypt? *Environmental Science and Pollution Research, 27*(10), 10869-10881. doi:https://doi.org/10.1007/s11356-019-07585-7
Khan, K., Su, C.-W., & Tao, R. (2021). Does oil prices cause financial liquidity crunch? Perspective from geopolitical risk. *Defence and Peace Economics, 32*(3), 312-324. doi:https://doi.org/10.1080/10242694.2020.1712640
Kuznets, S. (1955). American Economic Association. *The American Economic Review, 45*(1), 1-28.
Le, T.-H., Le, H.-C., & Taghizadeh-Hesary, F. (2020). Does financial inclusion impact CO2 emissions? Evidence from Asia. *Finance Research Letters, 34*(5), 101451. doi:https://doi.org/10.1016/j.frl.2020.101451
Lee, C.-C., & Wang, C.-W. (2021). Firms' cash reserve, financial constraint, and geopolitical risk. *Pacific-Basin Finance Journal, 65*(2), 101480. doi:https://doi.org/10.1016/j.pacfin.2020.101480
Liu, M., Ren, X., Cheng, C., & Wang, Z. (2020). The role of globalization in CO2 emissions: a semi-parametric panel data analysis for G7. *Science of the Total Environment, 718*(5), 137379. doi:https://doi.org/10.1016/j.scitotenv.2020.137379
Meirun, T., Mihardjo, L. W., Haseeb, M., Khan, S. A. R., & Jermsittiparsert, K. (2021). The dynamics effect of green technology innovation on economic growth and CO 2 emission in Singapore: New evidence from bootstrap ARDL approach. *Environmental Science and Pollution Research, 28*(4), 4184-4194. doi:https://doi.org/10.1007/s11356-020-10760-w
Mohsin, M., Zhou, P., Iqbal, N., & Shah, S. (2018). Assessing oil supply security of South Asia. *Energy, 155*(7), 438-447. doi:https://doi.org/10.1016/j.energy.2018.04.116
Narayan, P., & Smyth, R. (2005). Trade liberalization and economic growth in Fiji. An empirical assessment using the ARDL approach. *Journal of the Asia Pacific Economy, 10*(1), 96-115. doi:https://doi.org/10.1080/1354786042000309099

Nawab, T., Bhatti, M. A., & Nawaz, M. A. (2021). Does Technological Innovation Advance Environmental Sustainability in ASEAN Countries? *Pakistan Journal of Humanities and Social Sciences, 9*(3), 425–434-425–434. doi:https://doi.org/10.52131/pjhss.2021.0903.0148

Nawaz, M. A., Ahmad, T. I., Hussain, M. S., & Bhatti, M. A. (2020). How Energy Use, Financial Development and Economic Growth Affect Carbon Dioxide Emissions in Selected Association of South East Asian Nations? *Paradigms*(S1), 159-164. doi:https://doi.org/10.24312/20000123

Nawaz, M. A., Azam, A., & Bhatti, M. A. (2019). Natural resources depletion and economic growth: evidence from ASEAN countries. *Pakistan Journal of Economic Studies (PJES), 2*(2), 155-172.

Naz, S., Sultan, R., Zaman, K., Aldakhil, A. M., Nassani, A. A., & Abro, M. M. Q. (2019). Moderating and mediating role of renewable energy consumption, FDI inflows, and economic growth on carbon dioxide emissions: evidence from robust least square estimator. *Environmental Science and Pollution Research, 26*(3), 2806-2819. doi:https://doi.org/10.1007/s11356-018-3837-6

Pata, U. K. (2021). Linking renewable energy, globalization, agriculture, CO2 emissions and ecological footprint in BRIC countries: A sustainability perspective. *Renewable Energy, 173*(8), 197-208. doi:https://doi.org/10.1016/j.renene.2021.03.125

Pesaran, Y. S., & JS, R. (2001). BOUNDS TESTING APPROACHES TO THE ANALYSIS. Econometric Methods and Applications. In (Vol. 326, pp. 288-326).

Rahman, Z. U., & Ahmad, M. (2019). Modeling the relationship between gross capital formation and CO 2 (a) symmetrically in the case of Pakistan: an empirical analysis through NARDL approach. *Environmental Science and Pollution Research, 26*, 8111-8124. doi:https://doi.org/10.1007/s11356-019-04254-7

Sarkodie, S. A., & Strezov, V. (2019). Effect of foreign direct investments, economic development and energy consumption on greenhouse gas emissions in developing countries. *Science of the Total Environment, 646*(1), 862-871. doi:https://doi.org/10.1016/j.scitotenv.2018.07.365

Shafiq, M. N., ur Raheem, F., & Ahmed, A. (2020). Does Adaptation of Renewable Energy and Use of Service Industry Growth Diminution CO2 Emissions: Evidence of ASEAN Economies. *iRASD Journal of Energy & Environment, 1*(2), 61-71. doi:https://doi.org/10.52131/jee.2020.0102.0006

Shahbaz, M., Balsalobre-Lorente, D., & Sinha, A. (2019). Foreign direct Investment–CO2 emissions nexus in Middle East and North African countries: Importance of biomass energy consumption. *Journal of Cleaner Production, 217*(4), 603-614. doi:https://doi.org/10.1016/j.jclepro.2019.01.282

Shin, Y., Yu, B., & Greenwood-Nimmo, M. (2014). Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. *Festschrift in honor of Peter Schmidt: Econometric methods and applications*, 281-314.

Sweidan, O. D. (2021). The geopolitical risk effect on the US renewable energy deployment. *Journal of Cleaner Production, 293*(4), 126189. doi:https://doi.org/10.1016/j.jclepro.2021.126189

Tanveer, A., Anwer, M. A., & Umar, M. (2021). The impact of environmental sustainability and financial resources utilization on firm financial performance: the mediating role of leadership styles. *Annals of Social Sciences and Perspective, 2*(2), 389-407. doi:https://doi.org/10.52700/assap.v2i2.46

Tanveer, A., Song, H., Faheem, M., & Chaudhry, I. S. (2022). Validation of environmental Philips curve in Pakistan: a fresh insight through ARDL technique. *Environmental Science and Pollution Research*, 1-18. doi:https://doi.org/10.1007/s11356-021-17099-w

Tanveer, A., Song, H., Faheem, M., & Daud, A. (2023). The paradigms of transport energy consumption and technological innovation as a panacea for sustainable environment: is there any asymmetric association? *Environmental Science and Pollution Research, 30*(8), 20469-20489. doi:https://doi.org/10.1007/s11356-022-23453-3

Tanveer, A., Song, H., Faheem, M., Daud, A., & Naseer, S. (2021). Unveiling the asymmetric impact of energy consumption on environmental mitigation in the manufacturing sector of Pakistan. *Environmental Science and Pollution Research, 28*(45), 64586-64605. doi:https://doi.org/10.1007/s11356-021-14955-7

Terzi, H., & PATA, U. (2020). Is the pollution haven hypothesis (PHH) valid for Turkey? *Panoeconomicus, 67*(1), 93-109. doi:https://doi.org/10.2298/pan161229016t

Ulucak, R., & Khan, S. U.-D. (2020). Determinants of the ecological footprint: role of renewable energy, natural resources, and urbanization. *Sustainable Cities and Society, 54*(3), 101996. doi:https://doi.org/10.1016/j.scs.2019.101996

Wang, J., Zhang, S., & Zhang, Q. (2021). The relationship of renewable energy consumption to financial development and economic growth in China. *Renewable Energy, 170*(6), 897-904. doi:https://doi.org/10.1016/j.renene.2021.02.038

Wang, K.-H., Su, C.-W., & Umar, M. (2021). Geopolitical risk and crude oil security: A Chinese perspective. *Energy, 219*(3), 119555. doi:https://doi.org/10.1016/j.energy.2020.119555

Wang, K.-H., Xiong, D.-P., Mirza, N., Shao, X.-F., & Yue, X.-G. (2021). Does geopolitical risk uncertainty strengthen or depress cash holdings of oil enterprises? Evidence from China. *Pacific-Basin Finance Journal, 66*(4), 101516. doi:https://doi.org/10.1016/j.pacfin.2021.101516

Wang, Y., Li, K., Xu, X., & Zhang, Y. (2014). Transport energy consumption and saving in China. *Renewable and Sustainable Energy Reviews, 29*(1), 641-655. doi:https://doi.org/10.1016/j.rser.2013.08.104

Wang, Y., Zhang, D., Ji, Q., & Shi, X. (2020). Regional renewable energy development in China: A multidimensional assessment. *Renewable and Sustainable Energy Reviews, 124*(5), 109797. doi:https://doi.org/10.1016/j.rser.2020.109797

World Bank Developmnet Indicators. (2020). Retrieved from https://doi.org/World

Worldometer, C. C. (2021). Worldometer. 2020. *Update (Live)*.

Yang, K., Wei, Y., Li, S., & He, J. (2021). Geopolitical risk and renewable energy stock markets: An insight from multiscale dynamic risk spillover. *Journal of Cleaner Production, 279*(1), 123429. doi:https://doi.org/10.1016/j.jclepro.2020.123429

Zaidi, S. A. H., Hussain, M., & Zaman, Q. U. (2021). Dynamic linkages between financial inclusion and carbon emissions: evidence from selected OECD countries. *Resources, Environment and Sustainability, 4*(6), 100022. doi:https://doi.org/10.1016/j.resenv.2021.100022

Zakaria, M., & Bibi, S. (2019). Financial development and environment in South Asia: the role of institutional quality. *Environmental Science and Pollution Research, 26*(8), 7926-7937. doi:https://doi.org/10.1007/s11356-019-04284-1

Zhang, Y., & Zhang, S. (2018). The impacts of GDP, trade structure, exchange rate and FDI inflows on China's carbon emissions. *Energy policy, 120*(2), 347-353. doi:https://doi.org/10.1016/j.enpol.2018.05.056

Zhao, X., & Luo, D. (2017). Driving force of rising renewable energy in China: Environment, regulation and employment. *Renewable and Sustainable Energy Reviews, 68*(2), 48-56. doi:https://doi.org/10.1016/j.rser.2016.09.126

Zivot, E., & Andrews, D. W. K. (2002). Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis. *Journal of business & economic statistics, 20*(1), 25-44. doi:https://doi.org/10.1198/073500102753410372

Zubair, A. O., Samad, A.-R. A., & Dankumo, A. M. (2020). Does gross domestic income, trade integration, FDI inflows, GDP, and capital reduces CO2 emissions? An empirical evidence from Nigeria. *Current Research in Environmental Sustainability, 2*(12), 100009. doi:https://doi.org/10.1016/j.crsust.2020.100009