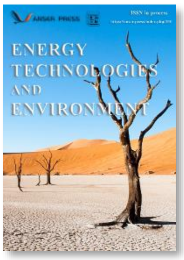
Energy Technologies and Environment 2023 1(1) 68-80

Energy Technologies and Environment
Homepage: https://www.anserpress.org/journal/ete



Energy, Economy, and Environment Nexus: New Evidence from China

Asif Raihan [a, *]

[a] *Institute of Climate Change, Universiti Kebangsaan Malaysia, Bangi, Malaysia*

ABSTRACT

At present, global warming poses the greatest threat to the planet's ecosystem. China is the greatest CO2 emitter, expected to account for roughly 33% of overall emissions in 2021, and this has caused authorities to express significant concern in the most latest Paris accord, when they decided to cut global emissions to a particular level. In comparison, 55% of China's power in 2021 appears from coal. As a result, investigating the ecological elements that affect China's CO2 output is essential. This analysis utilizes the autoregressive distributed lag (ARDL) technique to investigate the relationships concerning fossil fuels, renewables, and economic growth from 1990 to 2021. According to the data, using fossil fuels to generate energy and increase GDP significantly increases CO2 emissions. Yet, the use of renewable energy reduces CO2 emissions both in the long run and in the short term. Overall, the outcomes imply that using renewable energy sources is key to reaching sustainable environmental goals and deters the usage of fossil fuels in the energy mix. This study suggests that China take into account empirical findings and undertake long-term initiatives to reduce carbon emissions in favor of sustainable environmental outcomes.

KEYWORDS

Carbon emissions; fossil fuel; renewable energy; economic growth; sustainable development

---

* Corresponding author: Asif Raihan
E-mail address: asifraihan666@gmail.com

ISSN 2972-4899
doi: 10.58567/ete01010004

Received 13 March 2023; Accepted 5 July 2023; Available online 15 July 2023

1. Introduction

China's energy utilization soared from 397 million in 1978 to 3.65 billion tons of oil comparable in 2021, a compound yearly expansion rate of 5.5% (Raihan and Voumik, 2022a). At about the same time, the yearly growth rate of energy demand across the world was 2.9% (Voumik et al., 2022a). It is noteworthy that China's energy consumption growth rate has been much higher than the global average for 21 straight years. China is the leading consumer in the globe and has huge untapped growth potential; as a result, the country's per capita energy consumption is expected to rise dramatically in the coming years (Raihan et al., 2022a). If the Chinese government were to develop more ambitious green power projects in the country to keep up with rising energy consumption across the board, the country's energy conservation efforts would be met with significant obstacles (Raihan and Voumik, 2022b). From 20 million tons to 38 million tons, the global carbon emissions have increased dramatically during the past decade (Raihan and Said, 2022). China has targeted the year 2020 for the deployment of renewable energy sources. Taking into account the overall amount of power produced and the estimated share of renewable energy to production of power in aggregate, these objectives are ambitious (Raihan et al., 2022b). Decoupling the rising usage of fossil energy from trade development during the next few ages is an important goal of integrating innovative knowledges in China, as is reducing emissions and focusing on power resources (Raihan and Tuspekova, 2022a). The quality of the air and water in the area would likewise improve after such decoupling (Raihan et al., 2022c). Ecological pollution is expected to cost more than four percent of GDP.

The central government of China has set goals for sustainable energy use as part of its comprehensive energy and environment guidelines for the year 2020. Carbon intensity reduction goals include account for the impact of non-fossil fuel alternatives. The goal and regulations are to boost production of power from renewable sources like wind, solar, and biomass (Raihan et al., 2023a). The importance of understanding the relationship between renewables and China's major electricity and climatic strategy will become increasingly apparent as policymakers begin to think about reforms for the time beyond 2020. Coal and renewables both play a significant role in China's total electricity generation of 8,377 TWh in 2021, making China the earth's leading energy generator. Since 2009, it has been one of the world's leading sources of carbon emissions, responsible for almost a third of all CO2 released into the atmosphere (Ali et al., 2022). The Lawrence Berkeley National Laboratory in California has joined to the growing body of evidence suggesting China may reach peak carbon dioxide (CO2) output within the next twenty years. That's even more crucial for China. In significant part, the country's emissions trajectory will determine whether or not global targets to cut emissions to degrees a smaller amount possible to generate catastrophic climatic variation, such as further unadorned floods, droughts, and deluges that jeopardize yields and financial progress, are achieved (Begum et al., 2020). China, the planet's greatest emitter of greenhouse gases, may reach its emissions peak by 2030 or early, according to a report by US specialists, as the country's markets for electronics, constructions, and numerous businesses reach saturation across that period.

Because of its leading economy and recent transformation into a trade industry powerhouse, China is now known as the world's factory (Raihan, 2023a). According to the World Statistical Yearbook, out of the 500 primary industries commodities produced worldwide, China ranked first in production of 220 of them in 2016. This includes coal, steel, cement, shipbuilding, automobiles, and fertilizers. Fossil fuels are essential to the functioning of the industrial economy, which in turn has greatly aided in the expansion of the world's population (Raihan et al., 2018; Raihan et al., 2018; Raihan et al., 2023b). China's industrialization during the past fifty years has been heavily reliant on the use of coal. Between 1990 and 2021, national coal consumption increased from 1 billion tons to 4 billion tons. After 2011, coal consumption in China surpassed that of the rest of the world combined. The manufacturing sector in China is the largest consumer of coal (Raihan et al., 2022d). China's primary energy consumption broken down by fuel type is displayed in Figure 1. In 2021, coal will make up 55% of China's energy supply.

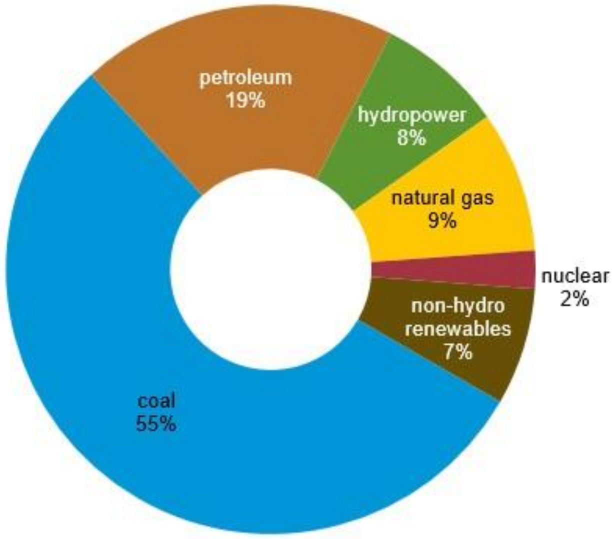


Figure 1. The breakdown of China's primary usage of energy by source in 2021.

In 2017, Chinese industry consumed over 95% of the country's electricity and reported using nearly two-thirds of the total energy. The burning of fossil fuels emits CO2 in the atmosphere, which the Intergovernmental Panel on Climate Change determined to be the primary driver of global climate change (Jaafar et al., 2020; Raihan et al., 2021a; Isfat and Raihan, 2022). For the time being, fossil fuels continue to supply more than 80% of global energy demand, making their use crucial for the prevention of climate change on a global scale (Raihan et al., 2021b; Raihan, 2023b). Misuse of natural energy, technological advancements, and the creation of rules and regulations adopted on a global scale are just a few of the many measures taken by authorities to reduce use of fossil fuels and carbon dioxide production (Raihan et al., 2022e). Accordingly, a scientific evaluation of the effectiveness of conserving the use of fossil fuels and the release of carbon dioxide emissions not only proposes a hypothesis and pledge to advance sustainable development, but also provides useful knowledge to reduce emissions (Raihan and Tuspekova, 2023b).

The importance of renewable energy has grown as a result of global warming and the diminution of conventional fossil fuels (Raihan et al., 2022f). Global energy conversion is increasing, which is good for innovation and development (Raihan et al., 2023c). The only approach to limit emissions and keep up with rising electricity demands is to increase efficiency (Raihan and Tuspekova, 2022c). Wind energy production and distribution potential has been slowly uncovered in China thanks to numerous surveys of the country's wind resources that have been conducted since the 1970s. The economy, climate, and energy are three factors that cannot be ignored during development (Raihan and Tuspekova, 2022d). For the past decade, China, the country with the highest per capita carbon emissions, has recognized the generation of renewable energy as a vital element in its efforts to enhance its energy configuration and reduce the amount of carbon it emits (Raihan and Tuspekova, 2022e). Thanks to a variety of procedures and expansion plans including clean energy legislation and the 13th Five-Year Renewable Energy Strategy, the amount of electricity that was generated from renewable sources increased from approximately 353.5 billion kWh in 2005 to 2.7 trillion kWh in 2022. This accounted for 31.6% of the country's total electricity consumption during that time period.

Credits to industrial innovations and improved reserve surveys, China's wind energy supplies have seen their potential for technological advancement increase from 253 GW in the later 1980s to 3.9 TW in 2018. As a result of the severe environmental problems and high economic costs associated with fossil energies, China has been making significant strides towards the production of alternative sources of energy. The Chinese government has set a goal to reduce emissions by 60-65% by the year 2030, despite the fact that emissions in the country are still increasing.

This means that the emissions peak will be passed by 2030, and further reductions will be implemented after that (Raihan and Tuspekova, 2022f). In order to raise carbon dioxide emissions and increase the proportion of energy generated from fossil fuels, China will need to boost the growth of its hydroelectric, wind, and solar power generation, as well as actively promote other forms of renewables for instance biofuels, geothermal, and oceanic power (Raihan et al., 2022g). China promotes electricity security by heavily investing in renewables while cutting back on traditional fuels. It might have a significant encouraging impact on achieving China's lofty goals and enhancing the condition of the natural environment if China were unable to reduce its emissions by 2030.

The above discussion demonstrates that there is little evidence supporting the factors that promote the application of renewable energy in China. Accordingly, it's motivating to examine the factors that play pivotal roles in both renewable and fossil fuels. In spite of these ecological restraints, China's electricity and environmentally responsive power manufacture knowledges are rising to the forefront of efforts to reduce carbon dioxide emissions from this country's energy sector. China is interested in this field because of the optimistic outlook for 2030. There are numerous energy and ecological problems that China must address. These include the country's high energy demand, reliance on fossil fuels, susceptibility to fluctuations in oil rates, and the acute deleterious effects of emissions from energy production on environmental quality. Based on this discussion, it appears that there are few supporting evidence for the claim that renewable energy consumption in China is on the rise. Consequently, this bolsters the need for in-depth research into the causes of environmental degradation. China's need for energy (both renewable and fossil fuel energy) is important to keep in mind for a number of reasons. More importantly, it is crucial for policymakers and governmental authorities to understand the factors that drive these energy sources. Having this kind of knowledge is crucial for developing efficient plans to address the rising energy demand and CO2 emissions (Raihan and Tuspekova, 2022g). In addition to this, it makes it easier for them to make the transition away from fossil fuels and toward renewable energy sources, which is critical for the sustained expansion of the economy (Voumik et al., 2022b). Also, it helps China accomplish its goals related to climate change and the reduction of carbon emissions.

This study contributes to expanding our understanding in a number of different ways. This analysis examines the relationship between fossil fuels, renewables, GDP, and carbon emissions for China from the period of 1990 to 2021. The data used in this investigation are the most recent and complete ones that are currently accessible for China. It promotes inclusive policy decisions on China's sustainable environment by helping stakeholders gain a more nuanced understanding of the interdependencies across factors. The ARDL approach, used here, allows researchers to examine how changing one predictor variable impacts another. With the results of this study in hand, the Chinese government will be better equipped to combat CO2 emissions by acknowledging the importance of renewable energy. Finally, this work makes a contribution to the existing body of research on environmental sustainability by examining the current connection between fossil fuels and environmental concerns. Co-integration between carbon emissions and their causes is discovered. Hence, the theory proposed that using fossil fuels for energy contributes to environmental degradation, whereas rising prosperity improves the environment through reduced carbon emissions.

2. Methodology

2.1. Data

Computational tasks are performed using a multivariate time series approach. Time series data from 1990 to 2021, which is publicly available (World Bank, 2023), is used in this analysis. The GDP and carbon dioxide emissions are also studied along with other energy sources and types. This information was gathered from the Global Development Indicators (WDI). The main advantage of annual secondary data is that the implications of seasonal variations are removed (Raihan and Tuspekova, 2022h). To eliminate heteroscedasticity, all series are transformed into a logarithmic process. Each variable's specifics are listed below in Table 1.

Table 1. Detailed explanation of the data.

Variables	Description	Logarithmic forms	Units
C	CO2 emissions	LC	Kiloton (kt)
F	Fossil fuel energy use	LF	Percentage of total final energy use
R	Renewable energy use	LR	Percentage of total final energy use
Y	Economic growth	LY	GDP (constant 2015 US$)

2.2. Stationarity check

To determine whether the dataset is unified at I(0) or I(1), this study first look at the associations between the answer variable and its explanatory components (1). Second, not all regressors need to have a seasonal influence or be included by order one. In addition, trying to steer clear of the I(2) sequence is invalid and may produce misleading results (Raihan and Tuspekova, 2022i). In addition, if any variable is nonstationary, the result may be erroneous. However, the switch to I(2) is unparalleled and causes concern for the small sample size (Raihan and Tuspekova, 2022j). The Augmented Dickey-Fuller (ADF), the Dickey-Fuller generalized least squares (DF-GLS), and the Phillips-Perron (P-P) unit root tests are used in this inquiry to ensure that no variables are I(2).

2.3. Empirical model generation and ARDL procedure

The co-integration of the variables was analyzed using the ARDL bounds test. The F-statistic, at the 5% significance level, measures the strength of the correlation over the long term. With co-integration, this study check to see if the estimated F-statistic is larger than the upper bound. This investigation can conclude that there is no long-term connection between the variables if the F-statistic is less than the lower critical bound. Assuming the calculated F-statistic falls anywhere in the middle of the upper and lower limits, the outcome is disappointing (Raihan et al., 2022h). The following is a description of the multiple regression equation at time t:

$$C_t = \tau_0 + \tau_1 F_t + \tau_2 R_t + \tau_3 Y_t + \varepsilon_t \tag{1}$$

where τ_0 is intercept and ε_t is error term. Additionally, τ_1, τ_2, and τ_3 are the coefficients.

The logarithmic representation of Equation (1) can be written out as follows:

$$\mathrm{LC_t} = \tau_0 + \tau_1 \mathrm{LF_t} + \tau_2 \mathrm{LR_t} + \tau_3 \mathrm{LY_t} + \varepsilon_t \tag{2}$$

The following equation describes how to carry out the ARDL bounds testing strategy:

$$\begin{aligned} \Delta LC_t = \tau_0 + \tau_1 LC_{t-1} + \tau_2 LF_{t-1} + \tau_3 LR_{t-1} + \tau_4 LY_{t-1} + \sum_{i=1}^{q} \gamma_1 \, \Delta LC_{t-i} + \sum_{i=1}^{q} \gamma_2 \, \Delta LF_{t-i} + \sum_{i=1}^{q} \gamma_3 \, \Delta LR_{t-i} \\ + \sum_{i=1}^{q} \gamma_4 \, \Delta LY_{t-i} + \varepsilon_t \end{aligned} \tag{3}$$

where Δ stands for the first difference operator, and q indicates the length of the lag that is optimal.

Pesaran et al. (2001) conceived of the ARDL bounds testing approach and developed it to compare and contrast results from long- and short-term studies. The ARDL model offers several benefits over time series models (Raihan et al., 2022i). For instance, while other co-integration methods require equal lengths of time between observations for the variables that are dependent and independent, this method can be used for both. For the ARDL model to work, the parameters must be mixed at either I(0) or I. (1). This inquiry found that co-integration occurs between parameters, which is consistent with the results of ARDL bound tests. In this investigation, the ARDL model with the Equation (3) is employed to investigate the ways in which different variables are connected across time. This research computed the short-run coefficients of the parameters using Equation (4) after establishing the long-term relationship between the series.

$$\Delta LC_t = \tau_0 + \tau_1 LC_{t-1} + \tau_2 LF_{t-1} + \tau_3 LR_{t-1} + \tau_4 LY_{t-1} + \sum_{i=1}^{q} \gamma_1 \Delta LC_{t-i} + \sum_{i=1}^{q} \gamma_2 \Delta LF_{t-i} + \sum_{i=1}^{q} \gamma_3 \Delta LR_{t-i} + \sum_{i=1}^{q} \gamma_4 \Delta LY_{t-i} + \theta ECT_{t-1} + \varepsilon_t \quad (4)$$

Using equation (4) as a guide, it can deduce the error correction term (ECT) to test how swiftly the system returns to equilibrium after a shock. In addition, the coefficient of ECT is represented by the symbol θ. There is typically no ECT over 1, and often none below 0. In cases where ECT is statistically significant and negative, it is crucial that the variance be adjusted to achieve equilibrium.

3. Results and discussion

Table 2 contains descriptive statistics; the peak is illustrated by kurtosis, and the data follow a normal distribution, as demonstrated by the Jarque-Bera test statistics. But, here is the bigger picture: CO2 emissions, fossil fuels, renewable energy, and GDP are all showing good trends.

Table 2. Descriptive statistics.

Variables	LC	LF	LR	LY
Mean	15.51674	4.420038	2.964153	29.15449
Median	15.62763	4.445163	2.827719	29.17715
Maximum	16.27503	4.487494	3.528817	30.39115
Minimum	14.59178	4.315245	2.428336	27.65803
Std. Dev.	0.575720	0.506146	0.414552	0.847209
Skewness	-0.152503	-0.486539	0.102098	-0.153931
Kurtosis	1.428648	1.729282	1.276846	1.748494
Jarque-Bera	2.416232	2.415472	2.614606	1.214730
Probability	0.181207	0.181276	0.134351	0.330429

The first step is to get certain that order one, I(1), contains the entire dataset, and more specifically the response variables. This is done by analyzing the strength of correlation that exists between the response variables and the predictor parameters. Next, it is not appropriate to include all of the regressors of order one or to demonstrate temporary unit roots. Both of these approaches are flawed. In order to evaluate the order of the variables and ensure compliance with the prerequisite, the ADF, DF-GLS, and P-P three-unit root tests were utilized. The results of the unit root tests are presented in Table 3. The data reveal that all the tested parameters are stationary at the initial difference. The data are consequently appropriate for ARDL estimator.

Table 3. The outcomes of unit root examinations.

Logarithmic form of the variables	ADF		DF-GLS		P-P	
	Log levels	Log first difference	Log levels	Log first difference	Log levels	Log first difference
LC	-1.043	-3.671***	-0.179	-3.906***	-1.007	-3.959***
LF	-2.679	-3.879***	-1.642	-3.967***	-1.726	-3.923***
LR	-1.501	-3.957***	-1.118	-3.842***	-1.247	3.947***
LY	-2.323	3.487***	-0.198	-3.189***	-2.158	-3.414***

*Notes: *** denotes significance at 1% level.*

After establishing the reliability of the variable's unit roots, the author of this study employs the ARDL bounds test to investigate the nature of the long-term connection that exists between the variables. The empirical findings of using the ARDL bounds testing approaches to cointegration are presented in Table 4. As the estimated F-statistic was higher than the values of the upper critical bound, the empirical data presented evidence that long-term cointegration did, in fact, exist among the variables in question.

Table 4. Results of ARDL bounds analysis.

F-bounds test		Null hypothesis: No degrees of relationship		
Test statistic	Estimate	Significance	I(0)	I(1)
F-statistic	21.36499	At 10%	2.37	3.20
K	3	At 5%	2.79	3.67
		At 2.5%	3.15	4.08
		At 1%	3.65	4.66

Table 5 reveals the long- and short-run outcomes of the ARDL estimation. The results reveal that the usage of fossil fuels for energy has a positive and significant impact on China's CO2 emissions. It has been shown that an expansion of 1% in fossil fuel energy advances to an expansion of 7.78 percent in CO2 emissions in the long run and 2.24 percent in the short run. When fossil fuels are burned, they release a wide range of air emissions that are harmful to the environment and public health (Raihan and Tuspekova, 2023a). China has enough power because to the planet's third-largest coal stockpiles and vast hydroelectric supplies. In 2021, coal will still be the primary supplier of power in China, reporting for 55 percent of the country's total power output. Mining and hydraulic fracturing are the two most common procedures for mining fossil fuels from the ground. Strong fossil fuels, such as coal, can be obtained through the process of mining by grinding, scrubbing, or uncovering hidden elements. Crude oil and natural gas are two examples of fossil fuels that can be obtained through the process of drilling methods. Both approaches have significant implications for people's health as well as the natural environment. Raihan and Tuspekova (2022k), who researched the effect of using fossil fuels as a source of energy on carbon emissions, came to very similar conclusions. When compared to other fossil fuels, coal produces the most carbon dioxide when burned. China currently uses more coal than any other country in the world to generate electricity, making it the largest contributor to global CO2 emissions. Specifically, the outcomes aid China's pursuit of the 2030 aim set forth in the Paris Agreement. It's a plan for preserving the planet for future generations that discourages using fossil fuels as a source of power.

Empirical findings reveal that renewable usage gives a negative and considerable consequence on environmental degradation in China over the long term. It follows that a 1% surge in renewable energy would drastically reduce CO2 emissions by 1.01% (long run) and 0.23% (short run). China now has more stringent CO2 reduction goals, with regional targets established. A greater investment in R&D that promotes technological progress in renewable energy is warranted, particularly in the regions with the highest carbon emissions (Raihan and Tuspekova, 2023b). Mounted solar, wind, and biomass-centered power competence is a primary aim of China's renewable energy policy. The present study's findings corroborate those of Raihan and Voumik (2022b), who reported a negative and significant result of renewables on China's carbon emissions.

Also, there is a significant link between GDP and carbon emissions, with a 1% increase in GDP leading to increases in CO2 emissions of 0.72 percent (long run) and 1.40 percent (short run). The results are in line with those of Raihan and Voumik (2022b), who found a positive and statistically significant correlation between China's GDP expansion and its CO2 emissions. Economic activities in developing nations typically contribute to environmental degradation because of their reliance on mining and other commercial endeavors that utilize fossil fuel energy supplies (Raihan, 2023c). Findings reveal that when China's industrial production and other economic activity increases, so do CO2 emissions. Nevertheless, renewable energy facilities generate power without contributing to air contamination (Raihan, 2023c). China's environmental problems can be mitigated thanks to the country's investment in renewable energy initiatives.

Table 5. ARDL results over the long and short term.

Variables	Long-run			Short-run		
	Coefficient	t-Statistic	p-value	Coefficient	t-Statistic	p-value
LF	7.7809***	6.8883	0.000	2.2392***	3.2207	0.001
LR	-1.0134***	-10.886	0.000	-0.2317***	-1.1536	0.003
LY	0.7211***	16.802	0.000	1.4029***	2.4926	0.002
C	31.962	7.1763	0.134	-	-	-
ECT (-1)	-	-	-	-0.5713***	-3.2206	0.000
R2	0.9998					
Adjusted R2	0.9996					

*Notes: *** denotes significance at 1% level.*

In addition, the ECT value is found to be significantly negative at a level of 1%. According to the value provided by the ECT, the average annual rate of change in the equilibrium was around 0.57%. According to the findings of the study, the predictor variables that were utilized can explain for 99% of the variation that was found in the response variable. This was determined by examining the R-squared values as well as the modified R-squared values.

Table 6 displays the empirical results of several diagnostic statistics. To ensure uniformly distributed residuals, the Jarque-Bera test can be utilized. The Lagrange multiplier (LM) technique utilized to the investigation of the serial correlation issue. Model free of serial correlation problem, as shown by the LM test result. The Breusch-Pagan-Godfrey analysis is utilized in the forecast model to investigate the heteroscedasticity issue. The conclusions of the Breusch-Pagan-Godfrey analysis designate that the predictable model does not suffer from heteroscedasticity. The model was determined to be well-founded using the Ramsey reset test.

Table 6. The findings obtained from diagnostic examinations.

Diagnostic tests	Coefficient	p-value	Decision
Jarque-Bera test	1.983834	0.3709	Residuals are normally distributed
Breusch-Godfrey LM test	2.466658	0.1303	No serial correlation exits
Breusch-Pagan-Godfrey test	0.510269	0.8875	No heteroscedasticity exists
Ramsey RESET test	0.523689	0.6100	The model is properly specified

As part of a comprehensive evaluation of the model's structural stability, the research uses the cumulative sum of recursive residuals (CUSUM) and the squares of cumulative sum of recursive residuals (CUSUMSQ) functions to determine the model's robustness. Figure 2 displays the visual representation of the CUSUM and CUSUMQ analysis. If the scatter plots don't deviate from the critical bound by more than 5%, for instance, then the model's parameters are stable. The graphs show that the CUSUM and CUSUMSQ values stayed within 5% of the allowed range for the whole study period.

4. Conclusions and policy implications

Because the consumption of energy is the principal source of carbon emissions, countries that have industrialized and countries that are still developing are both affected by the destruction of the environment. The world community has singled out China as the country that is the single largest contributor to the phenomenon of global warming. Managing environmental concerns while keeping the economy growing is another challenge China is facing at home. Participation in the Paris Accord, which requires China to lower the intensity of its emissions by between 60 and 65 percent, will have an impact on China's capacity to become a leading light in ecological

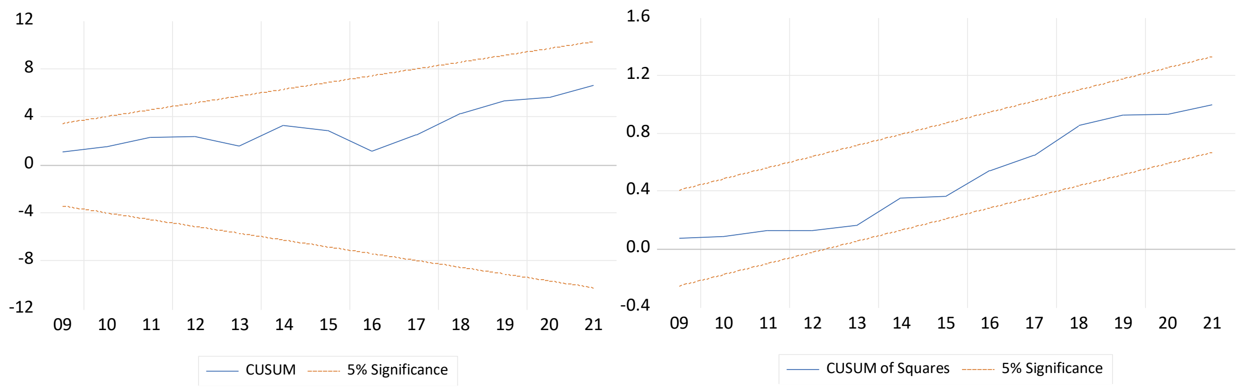


Figure 2. The findings of both the CUSUM and CUSUMQ analyses.

improvement and the big battle opposed to climate change. As a result, Chinese leaders have placed a greater emphasis on protecting the environment. This research set out to objectively examine the influence of China's GDP, energy utilization from renewables and fossil fuels on CO2 emissions between 1990 and 2021. In this inquiry, the ARDL method is utilized. This technique is able to accurately predict the genuine variance in the explanatory variables as well as their impact on the response variable. The ADF, DF-GLS, and P-P unit root tests are utilized over the course of this investigation to determine the integration order of the dataset. Using the ARDL bounds test, the study discovered that the variables do, in fact, have a long-term cointegration. Based on empirical study using the ARDL long- and short-run technique, it was found that increasing consumption of fossil fuels for energy and rising GDP both constitute a danger to environmental sustainability because of their positive influence on CO2 emissions. Renewable energy consumption is conducive to ecological sustainability since it reduces carbon dioxide emissions. Based on the findings of this study, officials are urged to devise plans to cut the massive amount of carbon that is projected to be emitted. Policymakers can do their part to combat climate change by promoting renewable energy resources like wind power, hydropower, and solar power and discouraging the use of fossil fuels.

The foregoing analytical results may have policy implications for China. The Chinese government should initially stimulate the production of green electricity in legislation and strategy in order to safeguard that the country's power system, economy, and climate all remain consistent and sustainable. So, it is not hard to foresee that reducing CO2 emissions will stimulate sustainable energy usage, which in turn will encourage sustained economic growth. In addition, we need to lessen our carbon footprint by bringing the levels of technology used in business and society up to par. To improve environmental sustainability, the Chinese government must strengthen regulations that support renewables and energy conservation. In particular, China needs to adjust its traditional energy consumption system, which is primarily based on the use of coal, along with boosting the quantity of renewables that is utilized in the western territory. To achieve long-term environmental objectives, the government should be urged to engage in clean energy efforts that may result in climate change. The carbon footprint of a country can be reduced by including renewables in the energy structure.

Given the results of using fossil fuels for energy, it is also recommended that the government promote CNG-fitted automobiles in order to reduce the region's reliance on fossil fuels, which would help maintain a human-friendly environment. The Chinese population is massive, and so too is the country's need for automobiles. In any case, it has significant bearing on the usage of fossil fuels and the production of greenhouse gases. Offsetting these negative consequences requires the efficient substitution of traditional fossil fuels with renewables. A good example would be for the Chinese government to enact regulations that encourage the development of hybrid vehicles while restricting the availability of gasoline and other fuels for traditional cars. Also, the Chinese government should tax fossil fuels to subsidize green energies nationwide. China also needs to implement a number of environmental rules, such as those that provide financial incentives to businesses that use cutting-edge pollution-control equipment. For the widespread adoption of cleaner technology, the country must also give an adequate boost in eco-friendly items. Increases in both output and, most importantly, the usage of renewable energy sources should inform policymaking efforts.

There are a number of discrepancies in policy, such as subsidies for oil and industrial safety, add to the environmental damage caused by emissions and economic expansion. Empirical findings that China's leadership prioritizes initiatives incorporating renewable energies and R&D to address the country's dire environmental situation inform policy recommendations. Strategies based on solar power have substantial promise for renewable energy savings. Clean energy generated by the wind is the easiest to access. A great deal of fossil fuels could be replaced in the long run by solar PV, which presents significant prospects. Substituting renewable energy for fossil fuels will help China reach its environmental sustainability goals. Last but not least, it is important to note that a lot of work has already been put into this study in order to reveal the function fossil fuel shows in ecological difficulties. Considering all of this, this study makes a major addition to the body of existing literature on energy, specifically in China. The key limitation of this investigation is the narrow scope of its investigation into energy issues at the national level. Hence, once data is collected at the level of the district as well as the province in China, following studies will analyze the signs that point to these various energy sources.

Funding Statement

This research received no external funding.

Acknowledgments

Not applicable.

Conflict of interest

The author claims that the manuscript is completely original. The author also declares no conflict of interest.

Author contributions

Conceptualization, data curation, formal analysis, methodology, visualization, writing: Asif Raihan.

References

Ali, A. Z., Rahman, M. S., and Raihan, A. (2022). Soil Carbon Sequestration in Agroforestry Systems as a Mitigation Strategy of Climate Change: A Case Study from Dinajpur, Bangladesh. Advances in Environmental and Engineering Research 3(4), 1-15. http://dx.doi.org/10.21926/aeer.2204056.

Begum, R. A., Raihan, A., and Said, M. N. M. (2020). Dynamic impacts of economic growth and forested area on carbon dioxide emissions in Malaysia. Sustainability 12(22), 9375. https://doi.org/10.3390/su12229375.

Isfat, M., and Raihan, A. (2022). Current Practices, Challenges, and Future Directions of Climate Change Adaptation in Bangladesh. International Journal of Research Publication and Reviews 3(5), 3429-3437.

Jaafar, W. S. W. M., Maulud, K. N. A., Kamarulzaman, A. M. M., Raihan, A., Sah, S. M., Ahmad, A., Saad, S. N. M., Azmi, A. T. M., Syukri, N. K. A. J., and Khan, W. R. (2020). The influence of forest degradation on land surface temperature–a case study of Perak and Kedah, Malaysia. Forests 11(6), 670. https://doi.org/10.3390/f11060670.

Pesaran, M. H., Shin, Y., and Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. Journal of applied econometrics 16(3), 289-326. https://doi.org/10.1002/jae.616.

Raihan, A. (2023a). Nexus between economic growth, natural resources rents, trade globalization, financial development, and carbon emissions toward environmental sustainability in Uruguay. Electronic Journal of Education, Social Economics and Technology 4(2), 55-65. https://doi.org/10.33122/ejeset.v4i2.102.

Raihan, A. (2023b). An econometric evaluation of the effects of economic growth, energy use, and agricultural value added on carbon dioxide emissions in Vietnam. Asia-Pacific Journal of Regional Science 7(1). https://doi.org/10.1007/s41685-023-00278-7.

Raihan, A. (2023c). Toward sustainable and green development in Chile: dynamic influences of carbon emission reduction variables. Innovation and Green Development 2, 100038. https://doi.org/10.1016/j.igd.2023.100038.

Raihan, A. (2023d). The dynamic nexus between economic growth, renewable energy use, urbanization, industrialization, tourism, agricultural productivity, forest area, and carbon dioxide emissions in the Philippines. Energy Nexus 9, 100180. https://doi.org/10.1016/j.nexus.2023.100180.

Raihan, A., and Said, M. N. M. (2022). Cost–benefit analysis of climate change mitigation measures in the forestry sector of Peninsular Malaysia. Earth Systems and Environment 6(2), 405-419. https://doi.org/10.1007/s41748-021-00241-6.

Raihan, A., and Tuspekova, A. (2022a). The nexus between economic growth, renewable energy use, agricultural land expansion, and carbon emissions: New insights from Peru. Energy Nexus 6, 100067. https://doi.org/10.1016/j.nexus.2022.100067.

Raihan, A., and Tuspekova, A. (2022b). Role of economic growth, renewable energy, and technological innovation to achieve environmental sustainability in Kazakhstan. Current Research in Environmental Sustainability 4, 100165. https://doi.org/10.1016/j.crsust.2022.100165.

Raihan, A., and Tuspekova, A. (2022c). The nexus between economic growth, energy use, urbanization, tourism, and carbon dioxide emissions: New insights from Singapore. Sustainability Analytics and Modeling 2, 100009. https://doi.org/10.1016/j.samod.2022.100009.

Raihan, A., and Tuspekova, A. (2022d). Dynamic impacts of economic growth, energy use, urbanization, tourism, agricultural value-added, and forested area on carbon dioxide emissions in Brazil. Journal of Environmental Studies and Sciences 12(4), 794-814. https://doi.org/10.1007/s13412-022-00782-w.

Raihan, A., and Tuspekova, A. (2022e). Dynamic impacts of economic growth, renewable energy use, urbanization, industrialization, tourism, agriculture, and forests on carbon emissions in Turkey. Carbon Research 1(1), 20. https://doi.org/10.1007/s44246-022-00019-z.

Raihan, A., and Tuspekova, A. (2022f). Towards sustainability: Dynamic nexus between carbon emission and its determining factors in Mexico. Energy Nexus 8, 100148. https://doi.org/10.1016/j.nexus.2022.100148.

Raihan, A., and Tuspekova, A. (2022g). Nexus between emission reduction factors and anthropogenic carbon emissions in India. Anthropocene Science 1(2), 295-310. https://doi.org/10.1007/s44177-022-00028-y.

Raihan, A., and Tuspekova, A. (2022h). Toward a sustainable environment: Nexus between economic growth, renewable energy use, forested area, and carbon emissions in Malaysia. Resources, Conservation & Recycling Advances 15, 200096. https://doi.org/10.1016/j.rcradv.2022.200096.

Raihan, A., and Tuspekova, A. (2022i). Dynamic impacts of economic growth, energy use, urbanization, agricultural productivity, and forested area on carbon emissions: New insights from Kazakhstan. World Development Sustainability 1, 100019. https://doi.org/10.1016/j.wds.2022.100019.

Raihan, A., and Tuspekova, A. (2022j). Nexus between energy use, industrialization, forest area, and carbon dioxide emissions: New insights from Russia. Journal of Environmental Science and Economics 1(4), 1-11. https://doi.org/10.56556/jescae.v1i4.269.

Raihan, A., and Tuspekova, A. (2022k). Nexus between economic growth, energy use, agricultural productivity, and carbon dioxide emissions: new evidence from Nepal. Energy Nexus 7, 100113. https://doi.org/10.1016/j.nexus.2022.100113.

Raihan, A., and Tuspekova, A. (2023a). The role of renewable energy and technological innovations toward achieving Iceland's goal of carbon neutrality by 2040. Journal of Technology Innovations and Energy 2(1), 22-37. https://doi.org/10.56556/jtie.v2i1.421.

Raihan, A., and Tuspekova, A. (2023b). Towards net zero emissions by 2050: the role of renewable energy, technological innovations, and forests in New Zealand. Journal of Environmental Science and Economics 2(1), 1-16. https://doi.org/10.56556/jescae.v2i1.422.

Raihan, A., and Voumik, L. C. (2022a). Carbon emission dynamics in India due to financial development, renewable energy utilization, technological innovation, economic growth, and urbanization. Journal of Environmental Science and Economics 1(4), 36-50. https://doi.org/10.56556/jescae.v1i4.412.

Raihan, A., and Voumik, L. C. (2022b). Carbon emission reduction potential of renewable energy, remittance, and technological innovation: empirical evidence from China. Journal of Technology Innovations and Energy 1(4), 25-36. https://doi.org/10.56556/jtie.v1i4.398.

Raihan, A., Begum, R. A., and Said, M. N. M. (2021a). A meta-analysis of the economic value of forest carbon stock. Geografia–Malaysian Journal of Society and Space 17(4), 321-338. https://doi.org/10.17576/geo-2021-1704-22.

Raihan, A., Begum, R. A., Mohd Said, M. N., and Abdullah, S. M. S. (2019). A review of emission reduction potential and cost savings through forest carbon sequestration. Asian Journal of Water, Environment and Pollution 16(3), 1-7. https://doi.org/10.3233/AJW190027.

Raihan, A., Begum, R. A., Mohd Said, M. N., and Pereira, J. J. (2021b). Assessment of carbon stock in forest biomass and emission reduction potential in Malaysia. Forests 12(10), 1294. https://doi.org/10.3390/f12101294.

Raihan, A., Begum, R. A., Nizam, M., Said, M., and Pereira, J. J. (2022a). Dynamic impacts of energy use, agricultural land expansion, and deforestation on CO2 emissions in Malaysia. Environmental and Ecological Statistics 29, 477-507. https://doi.org/10.1007/s10651-022-00532-9.

Raihan, A., Begum, R. A., Said, M. N. M., and Abdullah, S. M. S. (2018). Climate change mitigation options in the forestry sector of Malaysia. J. Kejuruter. 1, 89-98. http://dx.doi.org/10.17576/jkukm-2018-si1(6)-11.

Raihan, A., Begum, R. A., Said, M. N. M., and Pereira, J. J. (2022b). Relationship between economic growth, renewable energy use, technological innovation, and carbon emission toward achieving Malaysia's Paris agreement. Environment Systems and Decisions 42, 586-607. https://doi.org/10.1007/s10669-022-09848-0.

Raihan, A., Farhana, S., Muhtasim, D. A., Hasan, M. A. U., Paul, A., and Faruk, O. (2022c). The nexus between carbon emission, energy use, and health expenditure: empirical evidence from Bangladesh. Carbon Research 1(1), 30. https://doi.org/10.1007/s44246-022-00030-4.

Raihan, A., Muhtasim, D. A., Farhana, S., Hasan, M. A. U., Paul, A., and Faruk, O. (2022e). Toward environmental sustainability: Nexus between tourism, economic growth, energy use and carbon emissions in Singapore. Global Sustainability Research 1(2), 53–65. https://doi.org/10.56556/gssr.v1i2.408.

Raihan, A., Muhtasim, D. A., Farhana, S., Hasan, M. A. U., Pavel, M. I., Faruk, O., Rahman, M., and Mahmood, A. (2022d). Nexus between economic growth, energy use, urbanization, agricultural productivity, and carbon dioxide emissions: New insights from Bangladesh. Energy Nexus 8, 100144. https://doi.org/10.1016/j.nexus.2022.100144.

Raihan, A., Muhtasim, D. A., Farhana, S., Hasan, M. A. U., Pavel, M. I., Faruk, O., Rahman, M., and Mahmood, A. (2023a). An econometric analysis of Greenhouse gas emissions from different agricultural factors in Bangladesh. Energy Nexus 9, 100179. https://doi.org/10.1016/j.nexus.2023.100179.

Raihan, A., Muhtasim, D. A., Farhana, S., Pavel, M. I., Faruk, O., and Mahmood, A. (2022f). Nexus between carbon emissions, economic growth, renewable energy use, urbanization, industrialization, technological innovation, and forest area towards achieving environmental sustainability in Bangladesh. Energy and Climate Change 3, 100080. https://doi.org/10.1016/j.egycc.2022.100080.

Raihan, A., Muhtasim, D. A., Farhana, S., Rahman, M., Hasan, M. A. U., Paul, A., and Faruk, O. (2023b). Dynamic linkages between environmental factors and carbon emissions in Thailand. Environmental Processes 10(1), 5. https://doi.org/10.1007/s40710-023-00618-x.

Raihan, A., Muhtasim, D. A., Khan, M. N. A., Pavel, M. I., and Faruk, O. (2022i). Nexus between carbon emissions, economic growth, renewable energy use, and technological innovation towards achieving environmental sustainability in Bangladesh. Cleaner Energy Systems 3, 100032. https://doi.org/10.1016/j.cles.2022.100032.

Raihan, A., Muhtasim, D. A., Pavel, M. I., Faruk, O., and Rahman, M. (2022g). An econometric analysis of the potential emission reduction components in Indonesia. Cleaner Production Letters 3, 100008. https://doi.org/10.1016/j.clpl.2022.100008.

Raihan, A., Muhtasim, D. A., Pavel, M. I., Faruk, O., and Rahman, M. (2022h). Dynamic impacts of economic growth, renewable energy use, urbanization, and tourism on carbon dioxide emissions in Argentina. Environmental Processes 9, 38. https://doi.org/10.1007/s40710-022-00590-y.

Raihan, A., Pavel, M. I., Muhtasim, D. A., Farhana, S., Faruk, O., and Paul, A. (2023c). The role of renewable energy use, technological innovation, and forest cover toward green development: evidence from Indonesia. Innovation and Green Development 2, 100035. https://doi.org/10.1016/j.igd.2023.100035.

Voumik, L. C., Islam, M. J., and Raihan, A. (2022a). Electricity production sources and CO2 emission in OECD countries: static and dynamic panel analysis. Global Sustainability Research 1(2), 12-21. https://doi.org/10.56556/gssr.v1i2.327.

Voumik, L. C., Nafi, S. M., Kuri, B. C., and Raihan, A. (2022b). How tourism affects women's employment in Asian countries: an application of Generalized Method of Moments and Quantile Regression. Journal of Social Sciences and Management Studies 1(4), 57-72. https://doi.org/10.56556/jssms.v1i4.335.

World Bank. (2023). World Development Indicators (WDI), Data series by The World Bank Group, The World Bank: Washington, DC, USA. Retrieved from https://databank.worldbank.org/source/world-development-indicators.